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NOTES

ON THE

YEAR'S NAVAL PROGRESS.

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ERRATA.

Page 39, for HARNET read HORNET.

Page 46, line 9, for H read II.

Page 187, line 16 from the bottom, for "exprienced" read "experienced."

Page 197, line 10 from the bottom, and page 198, line 20 from the bottom, for "moter" read "motor."

Page 206, line 7 from the bottom, for "critizism" read "criticism."

Page 211, line 12, for "near" read "rear."

Page 211, line 5 from top, for "75" read "78;" line 12 from the bottom, insert the figures "15" and "16" in blank spaces.

Page 216, line 8 from the bottom, for "directiere" read "direction."

Page 214, lines 5 and 8 from the bottom; page 215, lines 8 from top and 14 from bottom; page 216, lines 5 and 11 from top, for "central stand" read "control stand."

Page 215, line 18 from bottom, for "hcists" read "hoist," and line 12 from bottom, for "determines" read "determine."

INTRODUCTION.

The publication of the Office of Naval Intelligence for this year continues the notes on professional subjects of the previous volumes, those on naval dynamo machinery being reprinted, by permission, from the Proceedings of the U. S. Naval Institute, Annapolis, Md., supplemented by some later notes from the author.

The modern marine boiler, a subject of universal interest at this time, is treated in Chapter VI, followed by a reprint of the published official report of the British Boiler Committee.

A valuable paper read last March before the Institution of Naval Architects in England by the Director of Naval Construction of the Admiralty is given, by permission, in Chapter VIII, and should be read in conjunction with Mr. White's remarks "On the designs for the new battle ships," on page 97, General Information Series No. VIII, July, 1889.

Chapter IX presents some of last year's manœuvers, including the principal tactical operations of the fleets of England, France and Italy, and in Chapter X this subject is treated with reference to the revolt in Brazil.

To the list of standard professional books some late works have been added; the list, however, has been considerably reduced by the omission of reference to books that are now issued to ships' libraries.

F. SINGER,
Chief Intelligence Officer.

I.

NOTES ON NAVAL ADMINISTRATION.

By Lieut. J. C. Colwell, U. S. Navy,
Staff Intelligence Officer.

The following charts are supplemental to previous articles published by this office (pages 225–310, General Information Series No. IX; 161–183, No. XI; 136–140, No. XII), and are intended to show graphically the organizations therein outlined, also the sequence of responsibility. All changes in organization which have been authorized up to date (June, 1894) have been incorporated. The latest and most complete reorganizations are those of Italy and Germany.

An inspection of these charts shows that practically the same great divisions exist in the organization of the naval departments of the chief European powers. A naval commander-in-chief, under the supreme executive, exists in the navies of Austria, France, Germany, Italy, and Russia. A concentration of all pertaining to the military part of the navy is made under one, or, if the general staff work is separated from that connected with the personnel, two heads. All connected with the *matériel* is concentrated under one, or, in some instances, two heads; and the administrative work is in most cases concentrated under the political representative of the executive power.

AUSTRIA.

All executive work connected with the personnel is concentrated in one division under a captain; all connected with the *matériel* in a second division under a captain, and has a division of operatives for general staff work under another officer of high rank. The technical committee is purely advisory to the commander-in-chief.

ENGLAND.

In England all that pertains to the military organization and training of the navy, and its preparation for, or use in war, is grouped under the three "sea lords," admirals or captains of the navy. All that

pertains to supplying the military organization with ships and their equipments of weapons and machinery is grouped under another admiral or captain. The administration of the shore establishments and the civil personnel is grouped under a civil lord of the admiralty.

FRANCE.

The entire organization is under the control of the chief of the general staff, who is the practical commander-in-chief of the navy. The organization and preparation of the navy for war, or general staff work, is his especial charge; the details connected with the personnel, its pay, supply, and education are concentrated under another admiral; all construction work of ships, engines, buildings, and harbors is under a director of construction; all ordnance work is under a general officer of marine artillery; and all accounts and estimates are under the chief commissary. The various consultative boards and commissions of officers of high rank are advisory to the minister of marine; and the chief of the general staff is in effect the executive officer of the navy department.

GERMANY.

The naval administration has two great divisions, one under the commanding admiral of the navy, charged with all the military work of the navy, and the other under the secretary of the navy, charged with all he administrative work. The emperor, through his naval staff, controls both branches, and adjusts their responsibility.

ITALY.

The naval department groups all administrative work under an assistant secretary; all the military work, except the general staff, which is under the assistant secretary, under an admiral, and, as in France, divides the *matériel* into two sections, one of ships and engines, and one of armament and equipment, which includes also coast defense.

RUSSIA.

All the military work is under the chief of the general staff, all *matériel* and supply under another admiral, and two strong advisory committees charged with all technical investigation and naval scientific work.

Ministry for War

Austria

The Emperor

The Naval Section

Chief - The Commander-in-chief of the Navy
(An Admiral)

Assistant Chief - A Vice Admiral

Staff { A Captain
Two Ensigns

At Vienna

The Private Cabinet
Chief Captain
Assistants
1 Commander
1 Lt-Commander
5 Lieuts
Correspondence — General organization training and discipline of personnel

Operations Division
Chief Captain
Assistants
1 Lt-Comdr
4 Lieuts
Advisory to Comdr-in-chief — Duties of the general staff — Distribution of the navy in peace and war — Manoeuvres — Mobilization — Intelligence office

First Division Personnel
Chief — A Captain

- First Section — Chief Commander — Assistants 3 Lieuts — Has charge of officer personnel
- Second Section — Chief Commander — Assistant 1 Lieut — Has charge of enlisted personnel
- Third Section — Chief Paymaster — Assistants 3 Paymasters — Administrative affairs of the division — Supplies — Clothing equipments stores etc.

Second Division Matériel
Chief — A Captain

- Fourth Section — Chief Captain — Assistants 2 Ship construction engineers, 1 Engine construction engineer, 2 Ordnance constr. engineers — All construction and equipment of ships, engines and ordnance — Advised by technical committee
- Fifth Section — Chief — A chief engineer of the corps of civil and hydraulic engineers — Assistant 1 paymaster — Administrative affairs of the civil and hydraulic engineers office at Pola
- Sixth Section — Chief Paymaster — Assistants 2 Paymasters — Administrative affairs of the division — Supplies — Coal for the navy and materials for construction of ships engines and ordnance

Seventh Section — Chief — A judge advocate with rank of colonel — Judge advocate general's office.

Eighth Section — Chief — The senior paymaster of the navy — Assistants 4 Paymasters — Accounts and disbursements of the navy — Preparation of budget

Office Management — Chief Lieutenant — Assistants 2 Lieuts, 1 Paymaster — Internal affairs of the navy department.

Registrar — Chief Paymaster — Assistants 2 Paymasters — Registration and archives office

Office of Naval Comptroller — Chief Captain — Assistant — Chief paymaster — Staff 20 Paymasters — Auditing and adjusting all naval accounts

At Pola

Technical Committee
(Advisory to Commander-in-chief)
President — A Rear Admiral
Vice President — A Captain
Staff — 3 Lieutenants, 1 Ship constr. engineer, 1 Engine " " , 1 Ordnance " " , 1 Paymaster

- First Sub-committee — Chief — A chief ship construction engineer, 1st class — Assistants 3 Ship construction engineers — Advisory to 4th section — Study of all technical questions connected with ship construction — Conduct experiments
- Second Sub-committee — Chief — The chief engine construction engineer — Assistants 3 Engine construction engineers — Advisory to 4th section — Same as 1st sub-com but with regard to engine construction
- Third Sub-committee — Chief — The chief ordnance construction engineer — Assistants 3 Ordnance construction engineers, 2 Lieuts — Advisory to 4th section — Same as 1st sub-com but with regard to ordnance construction
- Fourth Sub-committee — Chief — Commander — Assistants 3 Lieutenants, 1 Engine constr. engineer, 1 Ordnance construction engineer — Same as 1st sub-com but with regard to mobile torpedoes
- Fifth Sub-committee — Chief — Commander — Assistants 2 Lieutenants, 1 Mechanical engineer — Same as 1st sub-com but with regard to submarine mines
- Sixth Sub-committee — Chief — A chief electrical engineer of 2nd class — Assistants 1 Lieutenant, 1 Electrical engineer — Same as 1st sub-com but with regard to electricity
- Seventh Sub-committee — Chief — Commander — Assistant 3 Lieutenants — Same as 1st sub-com but with regard to hydrography and navigation

Office of Naval Health — Chief — The surgeon general of the navy — Assistant 1 medical officer — Duties of office of surgeon general

At Trieste

Office of Civil and Hydraulic Engineering — Chief — The civil and hydraulic engineer — Assistants 4 Civ and hyd engs, 3 Steam engineers, 8 Paymasters — Naval buildings, docks harbor works canals RR, gas and water connections — Supplies materials for same

Office of Description of the Coast — Chief — A captain — Assistants 1 Commander, 3 Lieutenants — Has charge of all data relating to the coasts from a military and naval standpoint.

Office of Naval Archives — Chief — A commander — Assistants 2 Lieutenants, 1 Paymaster — Collection and preservation of all naval documents plans etc.

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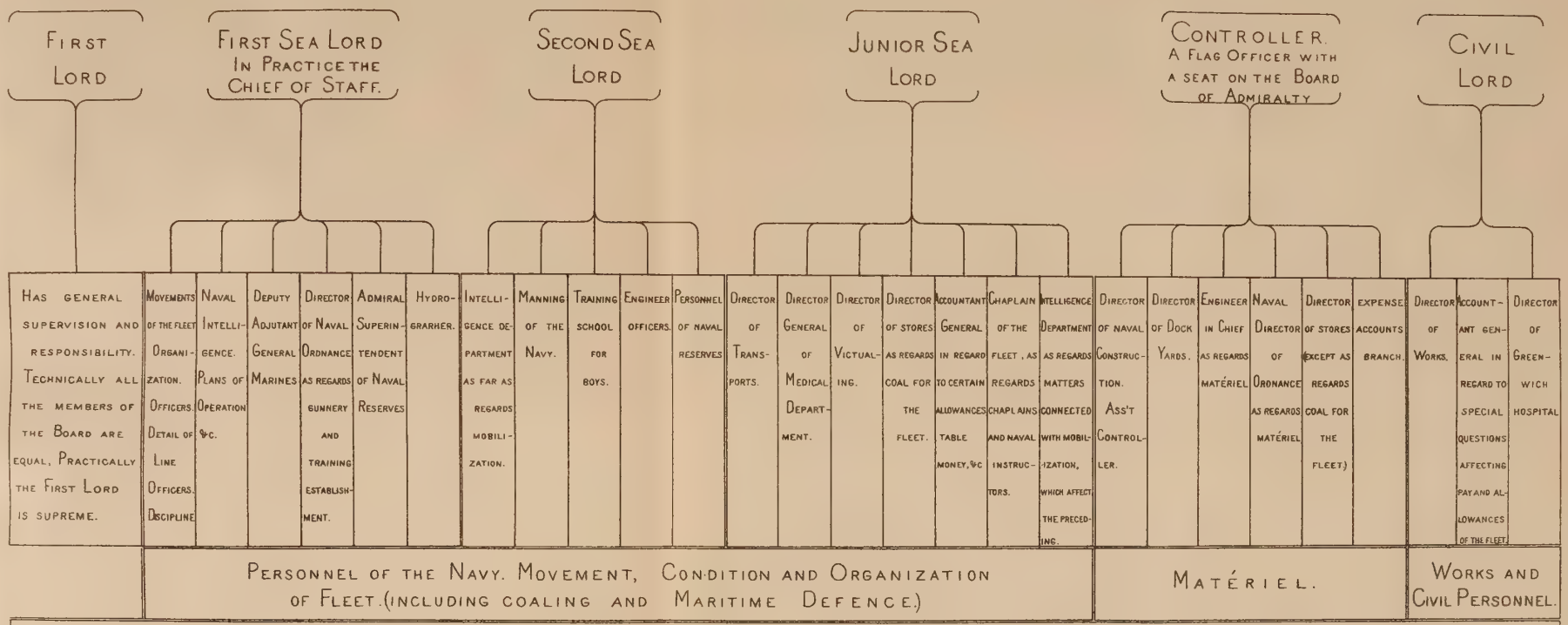
Admiralty England Organization



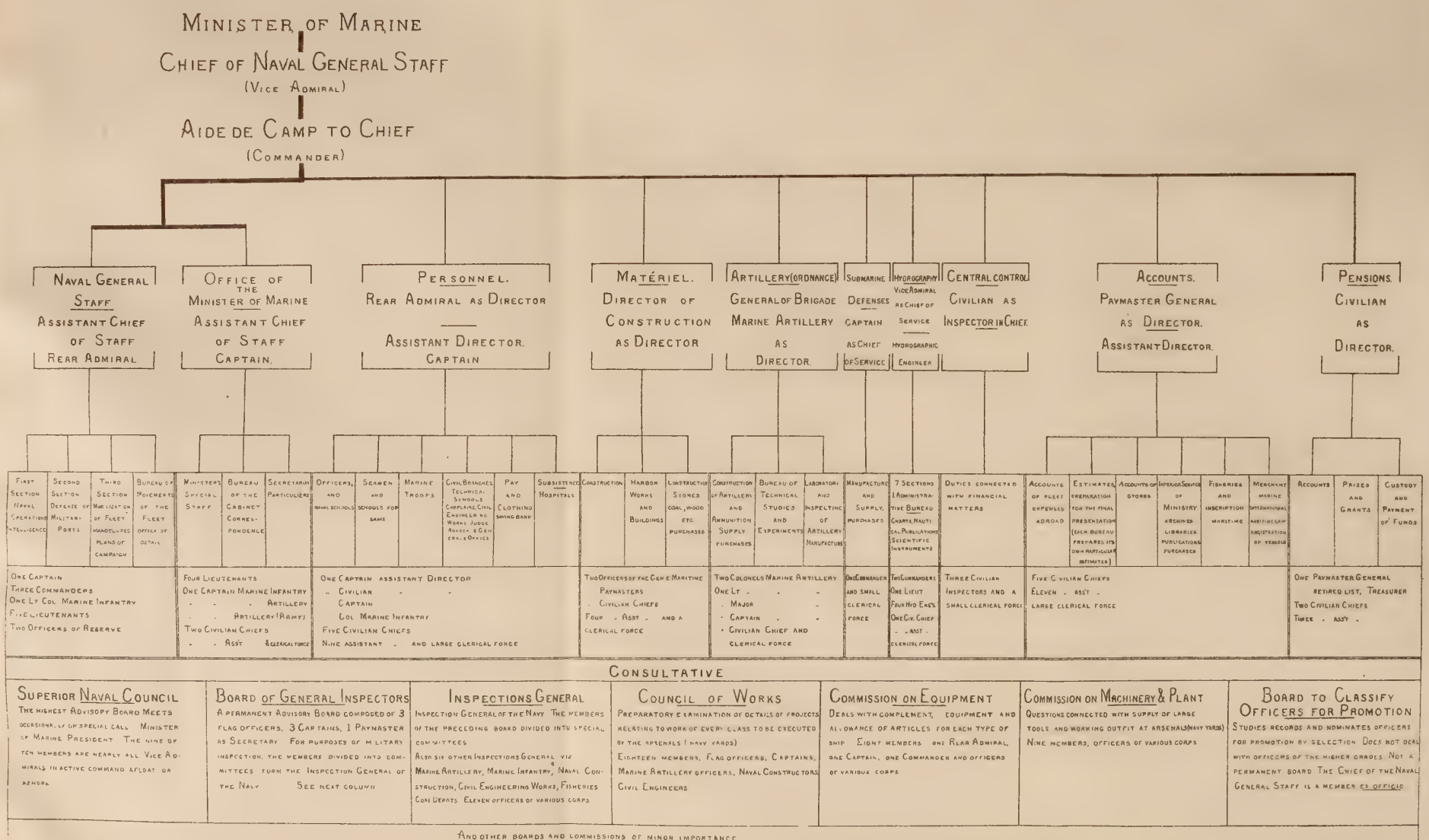
Financial Secretary.

Deals with all Financial questions, assisted by the Accountant General and the Director of Navy Contracts, the latter being also under the Superintending Lords, as regards purchases made for their several departments. A member of Parliament and of the party in office through whom all parliamentary statements are made in the House of Commons, unless the First Lord be a member of that house.

Permanent Secretary.

Superintends all correspondence in the name of the Board, prevents the various Departments acting independently, and provides for the due execution of Orders. All orders except those pertaining to the routine work of the Technical Departments, are signed by him in the name of the Board. All correspondence except that pertaining to the routine work mentioned, is addressed to the Secretary, opened in his office and referred for consideration and comment to all Departments concerned. The answers are formulated in the Central Secretariat and all such correspondence is filed there for reference.

Ministry of Marine
France
Organization



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ADMINISTRATION OF THE IMPERIAL GERMAN NAVY.

THE EMPEROR.

CHIEF COMMAND
THE COMMANDING ADMIRAL OF THE NAVY

CHIEF OF STAFF – A REAR ADMIRAL

STAFF
- 1 CAPTAIN
- 4 COMMANDERS
- 7 LIEUTENANTS
- 3 LIEUTENANTS J G

ADMIRALS STAFF SECTION	COMMAND SECTION	CENTRAL BUREAU	PERSONAL REPORTS	JUSTICE — CHIEF AN ADMIRALTY COUNCILOR	MEDICINE AND SURGERY — CHIEF THE SURGEON GENERAL
MOBILIZATION STRATEGY, TACTICS INFORMATION BUREAU	COMMISSIONING AND MOVEMENTS OF SHIPS ORGANIZATION TRAINING OR IMPROVEMENT OF THE PERSONNEL	BUSINESS TRANSACTIONS PERSONAL REPORTS ON OFFICIALS (NOT OFFICERS) UNDER THE CHIEF COMMAND	PERSONAL REPORTS ON OFFICERS, ENGINEERS AND CADETS TRAINING AND INSTRUCTION OF PERSONNEL BOTH MILITARY AND TECHNICAL	JUDGE ADVOCATE GENERALS DUTIES	HOSPITAL AFFAIRS PERSONAL REPORTS ON THE SURGEONS

THE NAVAL STATIONS OF THE BALTIC AND THE NORTH SEA CHIEFS – 2 ADMIRALS OR VICE ADMIRALS	INSPECTION OF NAVAL ARTILLERY (PERSONNEL) CHIEF – A REAR ADMIRAL	TORPEDO INSPECTION (PERSONNEL) CHIEF – A CAPTAIN	MARINE INFANTRY INSPECTION CHIEF A LIEUT COLONEL OR COLONEL	DIRECTION OF EDUCATION CHIEF – A REAR ADMIRAL	FLEETS, SQUADRONS, DIVISIONS AND FLOTILLAS	SHIPS ON FOREIGN STATIONS	HELGOLAND
	SAILOR ARTILLERY DIVISIONS AND GUNNERY SCHOOL SHIPS	TORPEDO DIVISIONS AND TORPEDO SCHOOL SHIPS	MARINES	NAVAL ACADEMY AND SCHOOL WARRANT OFFICER SCHOOL			

NAVAL INSPECTION CHIEF – A REAR ADMIRAL	CAPTAINS OF PORTS	WRECK COMMISSION	COMMANDANTS AT KIEL FRIEDRICHSORT WILHELMSHAVEN GEESTEMUNDE AND CUXHAVEN

SAILOR DIVISIONS	DOCK YARD DIVISIONS	BOY SECTION	RESERVE DIVISION	SCHOOL AND GUARD SHIPS
CAPTAINS — KIEL AND WILHELMSHAVEN	CAPTAINS KIEL AND WILHELMSHAVEN	COMMANDER KIEL		

NAVAL CABINET.
CHIEF

A REAR ADMIRAL

NAVAL AIDE DE CAMP TO EMPEROR

ASSISTANTS

1 COMMANDER

1 LIEUTENANT

2 CIVIL OFFICIALS

PERSONAL STAFF OF THE EMPEROR, AND IMMEDIATE ADVISORS — CO-ORDINATION OF THE WORK OF THE MILITARY AND ADMINISTRATIVE BRANCHES — TRANSMISSION OF PAPERS.

THE CHANCELLOR
OF THE GERMAN EMPIRE

THE SECRETARY OF STATE FOR THE NAVY
A VICE ADMIRAL

CENTRAL BUREAU CHIEF A CAPTAIN ASSISTANT A COMMANDER	MILITARY SECTION CHIEF A CAPTAIN ASSISTANTS 2 COMMANDERS 2 LIEUTENANTS	NAVAL DEPARTMENT CHIEF A VICE ADMIRAL ASSISTANTS 2 CAPTAINS 4 COMMANDERS 1 LIEUTENANT 4 CONSTRUCTORS & ENGINEERS	ADMINISTRATIVE DEPT CHIEF ADMIRALTY PRIVY COUNCILLOR	NAUTIGAL SECTION CHIEF A REAR ADMIRAL ASSISTANTS 1 CAPTAIN 1 COMMANDER	MEDICAL SECTION CHIEF THE SURGEON GENERAL	JUSTICE SECTION CHIEF ADMIRALTY COUNCILLOR
TRANSMISSION OF ORDERS CONDUCTS BUSINESS WITH PARLIAMENT CORRESPONDANCE	MOBILIZATION OF SHIPS — PREPARATION FOR SERVICE AND ORGANIZATION OF PERSONNEL EMPLOYMENT OF SHIPS	BUILDING OF SHIPS ENGINES, BOILERS, HARBOR AND WATER WORKS — CARE AND SUPPLY OF SHIPS OUTFITS OF GUNS, TORPEDOS AND MINES — SHIPS EQUIPMENT	ALL ADMINISTRATIVE MATTERS RELATING TO THE NAVY (EXCLUSIVE OF DOCK YARDS ADMINISTRATION) INCLUDING QUARTERS MESSING AND CLOTHING FOR THE PERSONNEL OF THE NAVY	SURVEYS CHARTS INSTRUMENTS, SAILING DIRECTIONS, PILOTAGE AND AIDS TO NAVIGATOR	ALL RELATING TO MEDICINE AND SURGERY AND HOSPITALS THAT DOES NOT COME UNDER THE CHIEF COMMAND	LAW AND JUSTICE, SUBSIDIES BOUNTIES ETC TO SHIPS

DOCK YARDS — COMMANDANTS REAR ADMIRALS	INSPECTION OF NAVAL ARTILLERY (MATERIAL AND ADMINISTRATION) CHIEF A REAR ADMIRAL	TORPEDO INSPECTION (MATERIAL AND ADMINISTRATION) CHIEF A CAPTAIN	SHIPS TRIAL COMMISSION CHIEF A CAPTAIN	CLOTHING OFFICES	STATION INTENDANCIES	INSPECTION OF COAST DISTRICTS	LIGHT HOUSE SERVICE CHIEF – ADMIRALTY COUNCILLOR
	COAST FORTIFICATIONS — HARBOR DEFENCE ARTILLERY AND MINE DEPOTS MANAGEMENT OF MATERIAL AMMUNITION.	TORPEDO EXPERIMENT — TORPEDO DEPOT TORPEDO FACTORY	TRIALS OF SHIPS AND NEW NAVAL DEVICES				

MESS OFFICES.	STATION TREASURIES	ACCOUNTING OFFICES	MANAGEMENT OF THE TREASURIES AND EXPENSES OF THE SCHOOLS.	ADMINISTRATIONS OF NAVAL GARRISONS.

Ministry of Marine
Italy

The Minister

"Superior Council of the Navy"

- 1 Vice Admiral (or admiral) — President
- 2 Vice Admirals
- 1 Chief Constructor of the Navy
- 1 Director General (Civilian) and
- The Chief of the Bureau or Office whose affairs are under consideration
- } Members
- 1 Rear Admiral or Captain — Member and Secretary

Secretaryship General
The Assistant Secretary of the Navy

- **Division of the Cabinet** — 1st Division — General concentration of work, revision of all correspondence, general orders, circulars etc. — Chief: Captain or commander
  - First Section — Chief: Lieut.-comdr or lieutenant — Publishes Giornale Militare; Navy Red Stick; Departmental correspondence; Contingent fund; Library
  - Second Section — Chief: Lieut.-comdr or lieutenant — Political correspondence; Secret service
- **Division of Departmental Service** — 2nd Division — Private secretaries and clerks of the minister and assistant secretary — Chief: Civilian
  - First Section — Chief: Civilian — Department personnel; Naval personnel in Rome; Budget
  - Second Section — Chief: Civilian — Running expenses of department; Printing
- **Office of the General Staff** — Chief: an admiral (vice or rear); Asst. Chief: captain; also such number of officers as may be needed — Preparations for war; Naval policy; Strategy; Tactics; Manoeuvres; Mobilization; Intelligence; Office; Reserves
- **Direction of Sanitary Service** — Chief: Medical inspector; Asst. Chief: medical director; Medical officer — Duties pertaining to the Surgeon General; Personnel of medical reserve
- **Office of Military Engineering** — Chief: Major General or Colonel of Army Engineers
  - First Section — Chief: Major Army Engrs — Construction and repair of Navy buildings and coast fortifications
  - Second Section — Chief: Computer Army Engrs — Leases; Contracts; Army; Personnel employed by the Navy Dept
- **Office of Examination of Accounts** — Chief: An inspector of commissariat (pay corps)
  - First Section — Chief: A pay director — Personnel of pay corps; Archives
  - Second Section — Chief: A commissary paymaster — Accounts of pay corps and its civil employees
  - Third Section — Chief: A commissary paymaster — Purchase of materials, provisions and ship stores
  - Fourth Section — Chief: A commissary paymaster — Verification of labor accounts
- **Office of Accounts** — 3rd Division — Chief: Civilian
  - First Section — Chief: Civilian — Accounts of naval funds; Records of contracts; All accounts; Payments of personnel; Expenses of mercantile marine
  - Second Section — Chief: Civilian — Payment of labor and material accounts; Inventory of government property

Direction General of Military Service
An admiral (vice or rear) — Director general

- **Division of Military Service** — 4th Division — Chief: Captain or commander
  - First Section — Chief: Lt.-comdr or lieut — Personnel of officers; Their orders; Officers out; Naval reserve
  - Second Section — Chief: Lt.-comdr or lieut — Organization; Discipline; Training; Ships except gunnery and torpedoes
  - Third Section — Chief: Civilian — Movements of ships; Hydrographical and meteorological services; Port service; Light house service; Naval academy; Machinists school
- **Division of Enlisted Men** — 5th Division — Chief: Civilian — Conscription service
- **Division of Corps Accounts** — 6th Division — Chief: Civilian — Crews of ships; Accounts of officers of the line, medical and pay corps; Accounts of store houses, hospitals, naval academy, machinists school and hydrographic service; Accounts of ships in commission

Direction General of Naval Construction
The inspector general of naval construction — Director general

- **Division of Naval Construction** — 7th Division — Chief: A director of construction or chief constructor (1st cl.) — Hulls and fittings; Ships data and records; Dock yard apprentice training
  - First Section — Chief: Chief constr. (2nd cl. or 1st class) of construction class — Hulls and fittings; Ships data and records; Dock yard apprentice training
  - Second Section — Chief: Chief (2nd cl.) — Personnel of construction corps and its reserve; Employees of the corps; Payment for labor
- **Division of Engines** — 8th Division — Chief: Same as 7th div. or mech. engr of same grade — New machinery; Engines for new ships; Acceptance; Steam trials; Engine data; Experiments and investigations; Supply of work shops and store houses; Engines of ships in service; Data of same; Supplies for same
  - First Section — Chief: Chief constr. (2nd cl. or 1st class) or mech. engr (2nd class) — Engines for new ships; Acceptance; Steam trials; Engine data; Experiments and investigations; Supply of work shops and store houses
  - Second Section — Chief: Same as 1st provided for 1st section
- **Division of Construction Accounts** — 9th Division — Chief: Civilian
  - First Section — Chief: Civilian — Accounts of construction; Accounts and engineers; Accounts and employees; Ship building; Accounts; Accounts of stores; Payments abroad
  - Second Section — Chief: Civilian — Bids and proposals for materials; Sale of old materials; Payments on contracts

Direction General of Ordnance and Equipment
An admiral (vice or rear) — Director general

- **Office of the Superior Technical Board on Guns, Torpedoes, & Equipment** — Chief: Captain; Secretary: Lt.-comdr or lieut — Investigation of scientific and technical questions of above subjects; Records of same; Collection of or special information of same
- **Division of Ordnance** — 10th Division — Chief: Captain or commander
  - First Section — Chief: Lt.-comdr or lieut — Guns; Small arms; Magazines; Installation of armament of ships and coast defenses; Signal fire works
  - Second Section — Chief: Lt.-comdr or lieut — Gunnery; Instruction of personnel; Studies and information on gunnery and ordnance
- **Division of Submarine Weapons and Electrical Material** — 11th Division — Chief: Captain or commander
  - First Section — Chief: Lt. comdr or lieut — Submarine weapons and materials; Installation of same on ships and for coast defense; Instruction of personnel in same
  - Second Section — Chief: Lt. comdr or lieut — Electrical materials; Its service and installation on board ships and for coast defense; Diving; Chemical service
- **Division of Equipment and Coast Defenses** — 12th Division — Chief: Captain or commander
  - First Section — Chief: Lt. comdr or lieut — Rigging, hawsers, and torpedo nets; Supply of technical equipment to ships and coast defense stations
  - Second Section — Chief: Lt.-comdr or lieut — Central office of the coast defense; Reports of com. mandants of coast defense stations; Study and preparation of plans for defense; Coast signal service
  - Third Section — Chief: Civilian — Equipment supplies for ships; Coal; Supply; Equipment; Store houses
- **Division of Accounts of Ordnance and Equipment** — 13th Division — Chief: Civilian
  - First Section — Chief: Civilian — Accounts of the technical personnel; Of the sailors; Ammunition; Of the gunnery and torpedo schools; Of labor and contractors; And of payments abroad
  - Second Section — Chief: Civilian — Bids and proposals; Sale of old materials; Payments on contracts

Direction General of The Mercantile Marine
A civilian — Director general

- **Office of General Affairs** — Chief: Inspector of ports or capt. of port 1st cl. — Commercial and navigation treaties; Inspection and measurement of vessels; Examination of mercantile officers
- **Division of Captains of Ports Maritime and Mercantile Marine Hospitals** — 14th Division — Chief: Civilian
  - First Section — Chief: Captain of port (2nd or 3rd cl.) — Personnel of capt. of ports; Port employees; Territorial maritime commission; Inspection of craft for port service
  - Second Section — Chief: Civilian — Maritime police; Pilots; Port charges; Hospital fund
  - Third Section — Chief: Civilian — Deeds of maritime merchant service; Deaths in merchant service; Merchant marine courses; Harbor works; Buildings; Fuel; Tugs; Etc.; Sanitary service of ports
- **Division of Ports and Shores and Maritime Grades** — 15th Division — Chief: Civilian
  - First Section — Chief: Captain of port (1st or 2nd cl.) — Examination for grades in the port service; Merchant marine courses; Lighters; Supervision of port improvements; Docks; Etc.; Ballast; Longevity; Dues on shore and afloat
  - Second Section — Chief: Civilian — Concessions for ship building; Dock establishments; Concessions for private docks; Dues on docks; Disposition of coast
- **Division of Premiums and War Time Taxes** — 16th Division — Chief: Civilian
  - One Section — Chief: Civilian — Application of maritime laws; Maritime taxes; Shipment and discharge of merchant ship men; Work on waters; Superintendence; Equipment; Prizes

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RUSSIA

THE EMPEROR

GENERAL ADMIRAL

[SUPREME COMMANDER OF THE NAVAL ESTABLISHMENT UNDER THE EMPEROR]

THE BOARD OF ADMIRALTY

PRESIDENT — THE GENERAL ADMIRAL

VICE PRESIDENT — THE MINISTER OF MARINE

MEMBERS
- 4 ADMIRALS
- 5 VICE (OR REAR) ADMIRALS
- 1 LIEUTENANT GENERAL (of NAVAL CORPS)

ADVISORY TO THE EMPEROR AND INSPECTION OF FLEET AND PERSONNEL

THE MINISTER OF MARINE

MINISTER — AN ADMIRAL APPOINTED BY THE EMPEROR

AIDE DE CAMP — A CAPTAIN

GENERAL STAFF
CHIEF OF STAFF
AN ADMIRAL OR VICE ADMIRAL
COMMANDER IN CHIEF OF THE FLEET FOR WAR OR MANŒUVRES
NAVAL STAFF
A REAR ADMIRAL AND
21 CAPTAINS, COMMANDERS & LIEUTENANTS

- **1st SECTION**
  CHIEF — THE CHIEF OF STAFF
  CONTROL OF THE ACTIVE FLEET
  MAN TARGET WAR PLANS
  MOB[illegible]
  INTELLIGENCE [illegible]
  REPLACE THE MINISTER OF MARINE IN [illegible] ABSENCE
- **2nd SECTION**
  CHIEF — THE ASST CHIEF OF STAFF (A REAR ADMIRAL)
  CONTROL OF THE ACTIVE PERSONNEL
  WORKS AND ACCOUNTS OF GENERAL STAFF
  REPLACE THE CHIEF OF STAFF IN HIS ABSENCE

CHIEF NAVAL JUDICIAL COURT
PRESIDENT
AN ADMIRAL

- MEMBERS
  4 ADMIRALS OR VICE ADMIRALS
  COURT OF FINAL APPEAL IN NAVAL JUDICIAL MATTERS

DIVISION OF MATERIALS AND SUPPLIES
CHIEF
A VICE (OR REAR) ADMIRAL
STAFF
27 OFFICERS AND CIVIL OFFICIALS

- **SECTION OF CONSTRUCTION**
  CHIEF — THE CHIEF OF DIVISION
  ASST'S 5 SHIP AND ENGINE BUILDING ENGINEERS
  SHIP AND ENGINE BUILDING AND REPAIRING
  ORDNANCE CONSTRUCTION
  DATA OF NAVIGATE AND FOREIGN SHIPS
  RESOURCES OF FOREIGN AND DOMESTIC PORTS
  ORDERS WORK AND MAKES CONTRACTS ADVISED BY TECHNICAL COMMITTEE
  LAYS OUT SHIPBUILDING AND ARMAMENT PROGRAMME
- **SECTION OF SUPPLIES**
  CHIEF A CIVIL OFFICER
  SUPPLIES MATERIALS PROVISIONS, CLOTHING AND FUEL
  MAKES CONTRACTS PROVIDES RESERVE STORES
- **SECTION OF ACCOUNTS**
  CHIEF — A CIVIL OFFICER
  ALL NAVAL ACCOUNTS, ESTIMATES AND DISBURSEMENTS

NAVAL TECHNICAL COMMITTEE
PRESIDENT
A VICE (OR REAR) ADMIRAL

MEMBERS
- THE CHIEF INSPECTOR OF ORDNANCE (REAR ADMIRAL)
- " " " " TORPEDOES (CAPTAIN)
- " " " " SHIP BUILDING ENGINEERS
- " " " " ENGINE BUILDING ENGINEERS
- 24 OFFICERS OF THE ABOVE BRANCHES
- 29 CIVIL OFFICIALS, INCLUDING ACCOUNTANTS

SIMILAR TO THE "COUNCIL OF WORKS" OF THE FRENCH MINISTRY AND TO THE "TECHNICAL COMMITTEE" OF THE AUSTRIAN MINISTRY

- **SUBCOMMITTEE ON ORDNANCE EXPERIMENTS**
  CHIEF — INSPECTOR OF ORDNANCE (MEMBER OF TECHNICAL COM.)
  ALL ORDNANCE DESIGN AND EXPERIMENT
- **COMMITTEE ON BUILDINGS**
  CHIEF — INSPECTOR OF CIVIL ENGINEERS
  NAVAL BUILDINGS DOCKS AND HARBOR WORKS
- **NAVAL MUSEUM**
  IN CHARGE
  A CIVIL OFFICIAL
- **DEPOTS OF MODELS AND PLANS**
  IN CHARGE
  A CIVIL OFFICIAL

NAVAL SCIENTIFIC COMMITTEE
PRESIDENT
A VICE (OR REAR) ADMIRAL

MEMBERS
- 3 VICE (OR REAR) ADMIRALS
- 3 CAPTAINS, COMMANDERS OR LIEUTENANTS
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CLASSIFICATION AND CARE OF ARCHIVES OF THE MINISTRY

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II.

NOTES ON SHIPS AND TORPEDO BOATS.

By Lieuts. E. J. Dorn and J. C. Drake, U. S. Navy,*
Staff Intelligence Officers.

ARGENTINA.

VESSELS LAUNCHED.

PATRIA.

In December, 1893, Messrs. Laird Bros., of Birkenhead, England, launched a steel twin-screw torpedo vessel for Argentina, which has been named the *Patria.* The vessel may be described as an enlarged and improved vessel of the *Halcyon* type in the British Navy (*see* p. 10, General Information Series, No. XI), the important departure being the substitution of a complete spar deck for the poop and forecastle.

Armament.—Two 4.7-inch R. F. G.,† one on the forecastle and one on the poop; four 8-pounders R. F. G., two on each broadside; two 3-pounders, one on each broadside; and two machine guns on the bridge. Five torpedo tubes, one fixed in the bow and two single tubes on each broadside, training 45 degrees forward and abaft the beam.

Motive power.—Two triple-expansion engines of 1,250 I. H. P. each, driving twin screws and giving an estimated speed of 20 knots.

Dimensions.—Length, 250 feet; beam, 30 feet; displacement, 1,183 tons.

STEAM TRIALS.

NUEVE DE JULIO.

(Page 60, General Information Series, No. XI.)

The speed made on acceptance trial, although noted on page 145, No. XII, is here given more in detail, by reason of this vessel representing

* Lieut. Dorn compiled the information from Austria, Denmark, England, Germany, Holland, Norway, Russia, Sweden, and Turkey.

† Rapid-fire guns.

an improved and successful type of protected cruisers. The particulars of the trial as furnished by the Argentine naval commission to the London *Engineering* in February, 1893, are as follows:

The contract speeds with natural and forced drafts were 21.5 knots and 22.5 knots, respectively. The steam trials included a continuous run of 6 hours' duration with open fire rooms, and in order to secure daylight for this trial the count was commenced some time before the engines had attained their maximum power. Notwithstanding this, the port engines indicated 53.827 revolutions and the starboard engines 52,932, which gave a mean of 148.3 revolutions per minute. The speed corresponding to this number of revolutions, obtained from a curve of revolutions and speed, was 21.94 knots. In the course of this trial a number of runs upon the measured mile took place, the mean revolutions per minute during these runs being 149.2 and the mean speed, taken in accordance with the British admiralty practice, was 22.028 knots. The mean I. H. P. developed during the 6 hours' trial reached approximately 10,300. The curve of revolutions and speed above referred to had been obtained by a series of progressive trials previously made. The vessel was run on the measured mile a number of times at various speeds, and a diagram was constructed by plotting the mean revolutions corresponding to each series of runs upon abscissæ representing the corresponding mean speed, and a curve was drawn through the points thus obtained. The vessel had maintained a speed of practically 22 knots over the 6 hours' run.

The Argentine commission attached very little importance to the forced-draft trial, and no endeavor was made to ascertain the utmost speed that could be attained by the vessel under such conditions; however, with very little additional pressure, several runs on the measured mile were made, when a power of about 14,500 I. H. P. was developed, and a mean speed of 22.74 knots was attained.

In a circular issued by the builders, Sir W. G. Armstrong, Mitchell & Co., it is stated that the *Nueve de Julio* on January 27, 1893, ran for 6 hours, natural-draft trial, frequently passing the measured mile, her speed being taken each opportunity, and a mean of the speeds was found to be 21.9 knots with 10,500 I. H. P.

It is also reported that the vessel did not have all her weights on board, that she was tried comparatively light and would not show such speed equipped for sea.

AUSTRIA.

The Austrian Naval Budget for 1894–'95 reaches a sum total of 12,477,680 guilders ($5,240,625), an increase over the budget of 1893–'94 of $210,000.

The appropriation for ordinary expenses, which includes the regular running expenses of the navy department, is $4,205,325. For extraordinary expenses, in which are included expenses which are to be met once, for the current year only, the sum is $1,077,300. Under the head of ordinary expenses there is appropriated for ship construction, engines, and boilers $415,800, which includes a second and last payment for the refit of the battleship *Custozza*; a second payment on the coast-defense vessel *A* (to replace the *Habsburg*); new engines and boilers for the monitors *Maros* and *Leitha*, and new boilers for the protected cruiser *Zara* and the schoolship *Saida*.

Under the head of extraordinary expenses the appropriation for ship-construction, engines, and boilers amounts to $661,500, and includes a fifth payment on the armored cruiser *Kaiserin und Königin Maria Theresia;* a second payment on the coast-defense vessel *B*, and the first payment on the coast-defense vessel *C*.

VESSELS PROPOSED OR LAID DOWN.

COAST-DEFENSE VESSELS, A, B.

(Page 146, No. XII.)

The keel of *A* was laid at the navy-yard, Pola, in June, 1893, and that of *B* at the Stabilimento Tecnico, San Rocco, Trieste, at about the same time. They have advanced far enough to receive their armor, which is now being delivered, and could be launched in the autumn, although they will probably not go into the water until the coming spring. They are to be completed in 1896 and 1898, respectively, and will cost about $1,470,000 apiece, exclusive of armaments.

COAST-DEFENSE VESSEL C.

This vessel, for which a first payment was appropriated, is building at the same yard as *B*, at Trieste, where her keel was laid in the spring of this year. She is a sister vessel of the preceding two, and is to replace one of the obsolete *Prinz Eugen* type. Considerable progress has already been made on her, as a large quantity of material had collected in anticipation.

These vessels will have a rather low free board and carry the heavy guns of the main battery in two barbettes placed on the center line forward and aft, and the lighter ones in an elliptical superstructure extending between the barbettes. The barbettes and superstructure occupy about two-thirds of the length of the vessel. There will be two military masts.

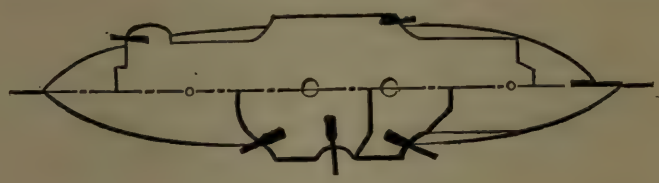
STEAM TRIALS.

TEGETTHOFF.

The refit of the battle ship *Tegetthoff* was completed in November, 1893, and the vessel subjected to her steam trials, with the following results:

		Natural draft.	Forced draft.
I. H. P		7,340	8,950
Speed	knots	15.2	15.5
Revolutions, mean		118.4	125.35
Air pressure	inch	.....	.48
Duration of trial	hours	6	6

In place of her former (bark) rig the *Tegetthoff* has now two military masts, of which the foremast carries two light signal yards and, at about one-third its height from the deck, a platform for a search light.



Armament.—Six 24-centimeter (9.4 inch) L/35 Krupp B. L.; five 15-centimeter (5.9 inch) L/35 Krupp R. F. G.; two 7-centimeter (2.75 inch) steel-bronze B. L.; fifteen 3-pounder R. F. G., and two machine guns.

The 9.4-inch guns are placed in an armored casemate, one at each corner, giving head and stern fire, and the remaining two in broadside. The former have electric as well as hand training gear; the latter train by hand only.

The 5.9-inch guns are carried on the upper deck and are mounted on C. P. mounts, with steel shields. One is placed in the bow under the forecastle, 2 are on the forward end of the casemate, and 2 are in sponsons. Of the fifteen 3-pounder R. F. G., nine, L/44, and two, L/33, are distributed about on the upper deck and stern gallery; four, L/33, are in the lower top. The machine guns are carried in the upper tops.

There are 4 search lights, each 23.6 inches in diameter, one for the platform on the foremast, and one on the chart-house on the superstructure deck. The remaining 2 projectors are carried in small turrets on the forward part of the main deck, thus permitting a strong beam to be thrown ahead and on each broadside.

Motive power.—The engines and boilers were built by the F. Schichau Company, of Elbing, but were placed on board at the navy-yard, Pola. There are 2 vertical triple-expansion engines having cylinders 33.8, 55, and 84.6 inches in diameter, with a stroke of 39.4 inches. The screws are 14 feet 9 inches in diameter, pitch 14 feet 7 inches. The 8 cylindrical boilers have 3 furnaces each and are placed in pairs in 4 separate compartments. They have a total grate surface of 538 square feet, a total heating surface of 19,975 square feet, and are designed for a working pressure of 156 pounds per square inch. There are also 2 auxiliary boilers for supplying steam to the auxiliary engines.

KÖRÖS.

The Danube monitor *Körös* passed a successful steam trial off Buda-Pesth.

VESSELS STRUCK FROM THE LIST.

Lissa, old type broadside battle ship; *Minerva*, sailing corvette; *Garguano*, transport and hospital ship; *Gemse*, gun vessel; *Thurm-Taxis*, paddle-wheel steamer; *Elizabeth*, dispatch vessel.

TORPEDO BOATS.

No appropriation for the increase of the torpedo boat flotilla was included in the budget, but a sum was voted for the repair of boilers of certain of the older boats.

BRAZIL.

By reason of the revolt, in September, 1893, of the greater part of the Brazilian navy, and with a view of subduing the insurgent ships, the legal Government, under President Peixoto, purchased abroad the following vessels:

GUSTAVO SAMPAIO (AURORA).

This torpedo vessel was sold by Sir W. G. Armstrong, Mitchell & Co., of Elswick, England, to the Brazilian agents in October, 1893, and not to Argentina, as formerly reported (p. 145, No. XII).

Armament.—Two 20-pounder, four 3-pounder R. F. G., and three torpedo tubes, one fixed in the stem, and one each broadside for training.

Motive power.—Engines of 2,300 I. H. P., giving a maximum speed of 17 knots.

Dimensions.—Length, 204 feet; beam, 20 feet; displacement, 500 tons.

NICTHEROY.

Formerly the United States merchant steamer *El Cid;* launched at Newport News in May, 1893, and converted into an unprotected cruiser at New York in November, 1893. Has a steel hull and was fitted with extra coal bunkers to protect the engines, boilers, and magazines.

Armament.—One 15-inch pneumatic dynamite gun on the forecastle; one 12-centimeter (4.7-inch) Hotchkiss R. F. G. on pedestal mount on poop; two 10-centimeter (3.94-inch) Hotchkiss R. F. G. on pedestal mounts, one on each side of pneumatic gun on the forecastle; eight 6-pounder and ten 1-pounder R. F. G.; two Hotchkiss R. C., four Howell torpedo tubes, and one Halpine dirigible torpedo.

Motive power.—Triple-expansion engines of about 4,000 I. H. P. driving a single screw, and giving a maximum speed of 19 knots.

Dimensions.—Length between perpendiculars, 389 feet 2 inches; beam, 48 feet; mean draught, loaded, 22 feet 6 inches; displacement, 7,080 tons.

ANDRADA (AMERICA).

This iron steamer was formerly the British merchant steamer *Britania.* She was launched at Bergen, Norway, in 1890, and converted into a cruiser at New York in November, 1893, and sailed from there under the name *America.*

Armament.—Two 12-centimeter (4.7-inch) Armstrong R. F. G. on the forecastle; two 14-pounder Hotchkiss R. F. G. on the poop; six

6-pounder and six 1-pounder R. F. G.; four Howell torpedo tubes and one Sims-Edison dirigible torpedo.

Motive power.—Triple-expansion engines of about 3,600 I. H. P. driving a single screw and giving a speed of about 17 knots under forced draft.

Dimensions.—Length, 254 feet; beam, 34 feet; mean draught, 18 feet; displacement, 2,600.

STEAM TRIALS.

BENJAMIN CONSTANT.

(Page 58, No. XI; 147, No. XII.)

In June, 1893, this vessel underwent steam trials. According to the terms of the contract with the builders, Forges et Chantiers de la Mediterranée, La Seyne, France, the consumption of coal at a speed of 10 knots should not exceed 143 pounds for each mile run, the duration of the trial being 6 hours. It was estimated that 59 revolutions per minute would produce a speed of 10 knots. However, on the day of trial, June 14, the sea was rough and it required 64 revolutions per minute to produce this speed. Nevertheless the consumption of coal did not exceed 84 pounds for each mile run under the above conditions. In January, 1894, the speed trials gave satisfactory results, the vessel maintaining a speed of 14 knots, natural draft.

With the exception of the battery the vessel has been ready for delivery for several months. This has been furnished by Sir W. G. Armstrong, Mitchell & Co., England, and after the successful gun trials in May, 1894, the vessel was finally accepted by the Brazilian authorities.

Armament.—The change made in the main battery (p. 147, No. XII), gives the following armament, which, for the rig and displacement of the vessel, 2,750 tons, is probably the heaviest R. F. battery afloat:

Four 15-centimeter (5.91 inch) R. F. G., two on forecastle and two on the poop; eight 12-centimeter (4.7 inch) R. F. G. in broadside in the waist; two 65-millimeter (12-pounder) R. F. G. on forecastle; six 25-millimeter R. F. G. and four 8 millimeter R. C. and four torpedo tubes mounted on berth deck. The vessel is ship-rigged, sheathed and coppered.

VESSELS LOST OR STRUCK FROM THE LIST.

Almirante, old type corvette, wrecked near Suez, Mediterranean Sea, in May, 1893. *Javary*, coast-defense vessel, a double-turreted monitor, sank in Rio harbor in November, 1893, presumably from a shot fired from Fort San João.

TORPEDO BOATS.

PIRATINY, POTY, INHANDUAY, MOXOTO.

The *Piratiny* was formerly Ericsson's torpedo boat *Destroyer*. Her hull, after purchase by Brazil in October, 1893, was hipped out amidships to increase the buoyancy, and, in addition to the Ericsson torpedo gun, the armament includes two 1-pounder Hotchkiss R. F. G. and one central pivot Howell torpedo tube.

The *Poty*, formerly the American steam yacht *Javelin*, was converted into a second-class topedo boat, being armed with two 1-pounder Hotchkiss R. F. G. and one Howell torpedo tube.

Inhanduay, formerly the American steam yacht *Feiseen*, a wooden canoe-shaped boat, built in 1893 by Messrs. Gardner & Mosher, of New York, was converted into a second-class torpedo boat, with an armament same as for the *Poty*.

Moxoto, a third-class Yarrow torpedo boat, purchased in England was equipped in New York in October, 1893. Armament same as for the *Poty*.

FIVE SCHICHAU TORPEDO BOATS.

In November, 1893, the agent of the Brazilian Government purchased 5 first-class torpedo boats from Mr. Schichau, of Elbing, Germany. They are 44-meter (144 feet 3 inches) boats, and displace about 130 tons, and carry 3 torpedo tubes and 2 Hotchkiss 37-millimeter R. C.

CHILE.

STEAM TRIALS.

BLANCO ENCALADA.

(Page 147, No. XII.)

In September, 1893, Sir W. G. Armstrong, Mitchell & Co., of Elswick, England, launched for Chile a protected cruiser, sheathed. The vessel has been named *Blanco Encalada*. She is the same type of vessel as the Japanese cruiser *Yoshino*, recently completed by the same builders, but, having a greater displacement, carries a heavier armament.

Armament.—Two 8-inch, one on forecastle and one on poop; ten 6-inch R. F. G. in sponsons, on a lower level, three on each side in waist, two on the bows, and two on the quarters; twelve 3-pounder and twelve 1-pounder R. F. G.; five torpedo tubes, and one third-class torpedo boat.

Protection.—A complete steel deck 1.75 inches thick on the flat and 4.5 inches on the slopes. A conning tower 6 inches thick.

Motive power.—Triple-expansion engines of 14,500 I. H. P., driving twin screws, and estimated to give a speed of 22.5 knots.

Dimensions.—Length, 370 feet; beam, 46 feet 6 inches; mean draught, 18 feet 6 inches; displacement, 4,420 tons.

In June, 1894, the vessel successfully completed the contract steam trials near the mouth of the Tyne. The natural-draft trial continued for 12 hours, and the mean of 6 consecutive runs over the measured mile, with and against the tide, gave a speed of 21.75 knots with about 11,000 I. H. P.

The forced-draft trial, which took place on another day, resulted in a mean speed of 22.78 knots on the measured mile, with and against the tide, the I. H. P. being about 14,500. The contract required 22.5 knots. It was also reported that the vessel turned through 360 degrees at full speed in 3 minutes 7 seconds, the diameter of the circle being 405 yards.

CHINA.

VESSELS PROPOSED OR LAID DOWN.

A steel cruiser of 2,200-tons displacement is building at the Fuchau arsenal. In February, 1894, her frames were in place. It is reported that China has ordered 4 torpedo vessels to be built in Germany.

DENMARK.

A handbook of the Royal Danish navy, recently published by authority of the minister of marine, contains the following information concerning the fleet of Denmark:

The fleet has been completely rebuilt during the past thirty years, only a few of the old vessels remaining in service at present. Of these the oldest is the *Dronning Marie*, launched in 1824, and the next oldest the *Schiödersee*, now used as a surveying vessel and over thirty-five years old. The latest vessel is a tug launched last year.

The total naval budget for the fiscal year ending April 1, 1895, amounts to 6,729,921 crowns ($1,803,618), a sum less by $184,750 than that appropriated last year, and includes for new construction an item of $321,600.

VESSELS PROPOSED OR LAID DOWN.

SKIÖLD.

Coast-defense vessel. An appropriation for a first payment on this vessel is included in the budget for this year.

At present there are on the stocks besides the *Skiöld* one third-class protected cruiser, *Heimdal*, and one patrol boat.

STEAM TRIALS.

GEISER.

(Page 47, No. IX; p. 55, No. XI.)

The trials of the *Geiser*, which took place in the sound at Copenhagen on October 27, November 2 and 5, 1892, are of especial interest, as this is the first war vessel of her size to be fitted with tubulous boilers of the *Thornycroft* type. The following particulars are taken from a letter directed to Messrs. J. I. Thornycroft & Co. by the director of naval construction of the Royal Danish navy and published in *The Engineer* (London), December 23, 1892:

The trials consisted of a 6 hours' coal-consumption trial, an 8 hours' speed trial, and a 4 hours' full-power trial. The mean results are as follows:

	Coal-consumption trial.	Sea-speed trial.	Full-power trial.
Date of trial	Oct. 27	Nov. 2	Nov. 5
Duration of trial ... hours	6	8	4
Displacement of ship ... tons	1,265	1,259	1,276
Collective I. H. P	1,744	2,422	3,157
Speed of ship ... knots	14.34	16	17.1
Revolutions, mean	204.7	227.9	250.6
Boiler pressure ... pounds	167.0	176.0	177.6
Vacuum ... inches	26.5	25.3	25.1
Air pressure ... do	.....	0.57	0.81
Coal consumption per hour in all boilers ... pounds	3,045	4,309	5,895
Coal consumption per hour per I. H. P ... do	1.75	1.77	1.87
Coal consumption per square foot of grate area ... do	17.8	25.2	34.5

During the trials the boilers worked most excellently. Steam was kept up with the greatest ease; the steam-generating power could be regulated nearly immediately to suit the steam consumption of the engines by means of the stop valves on the steam pipes of the fans. At the end of the sea-speed trial, for instance, we forced the engine up to 3,314 I. H. P. in a few moments, after having steamed over seven and a half hours, with an air pressure of about 0.6 inches, and could keep the steam at this high horse power with an air pressure of about 1 inch.

When going at full speed we often stopped the ship immediately, and we could bring the ship up to full speed in a few minutes, it being not necessary to take any regard whatever to the boilers, these being able to stand all sudden changes of temperature. The boilers never primed, neither during the highest forcing nor during sudden changes in the working of the engines. The great ease with which steam is formed in the boilers was most apparent on a trial at which we tried how quickly steam could be raised. The temperature of the water was 13 C. (55° F.) when fires were lighted and the gauge glasses three-quarters full. Fires were lighted at 8 hours 30 minutes; centrifugal pumps and fans were started with 8 pounds pressure in the boiler at 8 hours 54 minutes; steam pressure, 40 pounds per square inch, at 9 hours 4 minutes; steam pressure, 120 pounds per square inch, at 9 hours 11 minutes. At this time the engines were sufficiently warm to start them and the ship put to sea at 9 hours 13 minutes.

Thus the *Geiser* can be under way in less than three-quarters of an hour after lighting the fires; it could be done in less than half an hour if it were possible to warm the engines sufficiently in this time.

A comparison is made of the weights of the boilers of the *Geiser* with that of the sister ship *Hekla* (p. 323, No. VII), which has exactly the same engines and whose 6 low cylindrical boilers are designed for the same horse power.

	Hekla.	Geiser.
	Tons.	*Tons.*
Boilers with pipes, feed pumps, uptakes, funnels, and all other fittings in the boiler rooms	120.2	90.8
Water in boilers	48	17.4
Total	168.2	108.2

Thus 60 tons, or over one-third of the total weight of the boilers in the *Hekla*, are saved in the *Geiser*.

The *Geiser* is a protected cruiser and was launched at Copenhagen in July, 1892.

Her principal characteristics are as follows:

Armament.—Two 15-centimeter (5.9-inch) Krupp B. L.; four 6-pounder and six 1-pounder R. F. G.; four torpedo tubes, one in the bow, one in the stern, one in each broadside, all fixed; two search lights.

Protection.—Complete steel protective deck, 0.75 to 1.25 inches thick; glacis 6 inches around engine room, at an angle of 45 degrees; conning tower, 4.5 inches; ammunition tubes, 1.6 inches.

Motive power.—Two sets of vertical, triple-expansion engines; 8 water-tube boilers, arranged in 2 fire-rooms, and 2 smoke-pipes. The cylinders are 19, 30, and 50 inches in diameter with 18-inch stroke; diameter of screw, 8.5 feet; pitch, 7.59 feet. The total tube surface of the boilers is 12,100 square feet, and the total grate area 171 square feet; coal capacity, 125 tons.

Dimensions.—Length, 231 feet 8 inches; beam, 33 feet 8 inches; mean draught, 11 feet 2 inches; displacement, 1,280 tons.

ENGLAND.

The navy estimates for the fiscal year ending March 31, 1895, amount to a net total of £17,366,100 ($84,399,246), or $15,192,360 more than the sum voted for 1893–'94.

The total estimated provision for new construction, including armaments, is $30,999,850, in addition to which there is also available for dockyard shipbuilding, savings on shipbuilding and armaments of previous years under the naval-defense acts, about $1,045,460, making a total of $32,045,310.

The amendments to the naval-defense act extended by one year the time for the completion of the vessels provided for in that act and appropriated the additional sum of $6,561,000 therefor. Of the 70 ves-

sels comprising that programme all are completed but the protected cruisers *Flora*, *Fox*, and *Forte*, and these will be finished before the end of the year.

The new vessels, for which provision was made in the estimates for 1893–'94 (p. 149, No. XII), were apart from any formulated programme, and are treated separately in the present estimates, forming an item of $22,691,665 of the sum total.

In the statement of the first lord of the Admiralty, explanatory of the navy estimates for 1894–'95, Earl Spencer says:

> The new scheme of construction for 1894–'95 forms part of a complete programme which has been arranged for a term of five years. The programme has been settled upon after a careful review, not only of the present relative strength of our navy as compared with that of other powers, but also of the number and class of ships of war which are now being built abroad.

The secretary to the Admiralty recently stated in reply to a question in Parliament:

> It was most certainly the intention of the Government to make our fleet at least equal to the united navies of the two greatest maritime powers.

In concluding his statement Earl Spencer says:

> We do not propose to extend to the new programme of shipbuilding financial machinery like that of the naval-defense act. Apart from financial policy and other considerations connected with it, the accounts rendered necessary by the act have proved difficult and complicated in their working, and I trust that by careful and energetic management the funds placed at the disposal of the Admiralty in their annual votes will secure the rapid and economical prosecution of shipbuilding work for the navy.

VESSELS PROPOSED OR LAID DOWN.

A new programme has been brought forward by the Government looking toward a further increase of the navy on very liberal lines. It contemplates a total of 110 vessels of all types and spreads over a term of five years, beginning with the current fiscal year and ending March 31, 1899.

BATTLE SHIPS.

Ten battle ships of about 14,900 tons displacement are included, 5 to be finished in 1897–'98 and 5 in 1898–'99. Seven of these are included in this year's budget and the remaining 3 are to be provided for in the estimates for next year. They will be of the *Majestic* type, of about 14,900 tons displacement.

Six battle ships of about 6,000 tons are also contemplated. Their designs are to have neither turrets nor barbettes, but are to be completely armored on the broadside and carry their guns in casemates.

PROTECTED CRUISERS.

Two protected cruisers of the *Powerful* type are to be laid down next year, to be finished in 1897–'98, and 2 more, which may also be laid down at the end of next year, are to be finished in 1898–'99. Whether more

of these cruisers are to be added will depend upon what Russia and France may do in the meantime.

Six protected cruisers of the *Talbot* type to be laid down this year are to be finished in 1895–'96; 8 to be laid down in that year are to be finished in 1897–'98, and 10 to be laid down in 1896–'97 will be completed in 1898–'99.

UNPROTECTED CRUISERS.

Twelve of these are included in the programme, of which 2 of the *Linnet* type are provided for in this year's budget.

A design is being prepared for a third-class cruiser of the *Bellona* type, and if approved some of these vessels are to be put in hand in 1896–'97.

Excluding the vessels not yet designed, the new programme therefor contemplates the completion of 4 vessels of all classes in 1895–'96, 10 in 1896, 15 in 1897–'98, and 17 1898–'99.

MAGNIFICENT, MAJESTIC.

The keel of the *Magnificent* was laid in the Government yard, Chatham, on December 12, 1893; that of the *Majestic* at Portsmouth on February 5, 1894. Both vessels were designed by Mr. W. H. White. They are to be improvements on the *Royal Sovereign* type (p. 15, No. X; 15, No. XI) with the same breadth and draught of water, but about 10 feet longer, and will carry their heavy guns forward about 4 feet higher, the free board being correspondingly increased. They will be practically of the same speed as the *Royal Sovereign*, and are designed to carry the same amount of coal, 900 tons, at load draught, but their bunker capacity will be greatly increased, so that with the full supply on board their coal endurance will be much greater and they will be able to keep the sea for longer periods.

Armament.—Four 12-inch B. L. wire-wound guns L/40, mounted in pairs; twelve 6-inch R. F. G.; sixteen 12-pounder and twelve 3-pounder, R. F. G. There will be five torpedo tubes, four being under water. The general disposition of the armament follows up that of the *Royal Sovereign*, with certain important differences.

The 12-inch guns will be mounted in armored barbettes and provided with heavy shields, which will revolve with the gun; the mounts will be so arranged that the guns can be loaded in any position by hand and by hydraulic power, the fixed loading stations being, however, also retained.

Protection.—The total weight of protective material on the hull, including the protection of the 6-inch guns and protective deck, is greater than the corresponding weight in the *Royal Sovereign* type, and although the substitution of 12-inch for 13.5-inch guns, and the improved quality of the armor to be used have affected a considerable reduction in weights, the aggregate result of the changes has been to add materially

to the total load to be carried by the new vessels, and an increase of length has therefore been necessary.

Motive power.—Triple-expansion engines designed to develop 12,000 I. H. P. with forced draft and 10,000 with natural draft; speed, 17.5 and 16 knots.

Dimensions.—Length, 390 feet; extreme breadth, 75 feet; mean draught, 27 feet 6 inches; displacement, 14,900 tons.

PRINCE GEORGE, VICTORIOUS, HANNIBAL, CÆSAR, MARS, JUPITER, ILLUSTRIOUS.

The first of these is to be laid down at Portsmouth, where also the *Cæsar* is to be built when her design is completed. The *Victorious* has been laid down at Chatham, where the *Illustrious* will also be built. The *Hannibal* has been laid down at Pembroke, and the *Mars* at the yards of Messrs. Laird Bros., Birkenhead. The *Jupiter* will be built by Messrs. J. & G. Thomson, Glasgow.

Their designs are by Mr. W. H. White, C. B., director of naval construction, and they will all be of the *Majestic* type, armed with four 12-inch B. L. in pairs, in barbettes, and twelve 6-inch R. F. G. They will have partial belts of steel armor, Harveyed. Their engines are designed to develop 12,000 I. H. P. with forced draft, and give a speed of 17.5 knots.

POWERFUL, TERRIBLE.

(Page 149, No. XII.)

The contracts for building these protected cruisers have been placed with the Naval Construction and Armaments Company, Barrow-in Furness, and with Messrs. J. & G. Thomson, Glasgow, respectively, where work has been begun upon them. They are to be improvements on the Edgar type (pp. 14 and 16, No. X; p. 13, No. XI), and will have great height of freeboard with a long forecastle and poop, upon which the bow and stern guns are to be carried, thus securing not only the power of fighting the guns in heavy weather, but also that of maintaining the speed under those circumstances. The hulls are to be sheathed with wood, and coppered. They are to be completed in three years.

Armament.—Two 9.2-inch guns mounted as bow and stern chase; twelve 6-inch R. F. G. in broadside, four to fire right ahead and four to fire right astern; twenty-eight smaller R. F. G. The torpedo armament includes four submerged torpedo tubes, placed in separate rooms.

Protection.—Complete steel protective deck with a maximum thickness of 4 inches tapering to 3 on the extremities.

Motive power.—Twin-screw triple-expansion engines capable of developing, with natural draft 25,000 I. H. P. and a speed of 22 knots. After a series of exhaustive experiments the Admiralty have decided to fit both these vessels with Belleville boilers. Coal capacity at load draught 1,500 tons; total bunker capacity, 3,000 tons.

Dimensions.—Length, 500 feet; breadth, 71 feet; displacement, 14,200 tons.

VENUS, DIANA, JUNO, DORIS, IRIS, DIDO.

(Page 149, No. XII.)

The contracts for the first two of the protected cruisers, *Talbot* type, have been awarded to the Fairfield Shipbuilding Company, Govan; the second two to the Naval Construction and Armaments Company, Barrow-in-Furness; and the others to the London and Glasgow Engineering and Shipbuilding Company, Glasgow.

They will be of about 5,600 tons displacement, and carry a battery of five 6-inch and six 4.7-inch R. F. G.; their engines are designed to develop 9,600 I. H. P., with forced draft, giving a speed of 19.5 knots.

PHŒNIX, ALGERINE.

These names have been given to the two twin-screw sloops of the *Linnet* type, improved and enlarged. They will be laid down at Devonport and are intended for service in Chinese waters. They will be of about 1,050 tons displacement and carry a battery of six 4-inch R. F. G. and four 3-pounders.

DROMEDARY.

A powerful sea-going tug of this name, for use at Portsmouth, has been ordered by the Admiralty from Messrs. Barclay, Curle & Co., Glasgow. She is from the design of Mr. W. H. White, and is to be completed during the present year. Her dimensions are: Length, 144 feet; breadth, 27 feet 3 inches; mean load draught, 10 feet 9 inches; displacement at load draught, 680 tons. The engines, building by the same firm, are to be capable of developing with natural draft 1,250 I. H. P. The coal capacity at load draught will be 80 tons, but when required a considerably larger quantity can be put on board.

VESSELS LAUNCHED.

FLORA, FORTE, HERMIONE.

(Page 14, No. X.)

Protected cruisers; the *Flora* was launched at Pembroke November 21, 1893. Flush spar deck, double bottom with water-tight compartments. Electric lighting.

Armament.—Two 6-inch R. F. G. on the forecastle and poop. Eight 4.7-inch R. F. G., in broadside, eight 6-pounder and one 3-pounder R. F. G., and four Nordenfelt machine guns; four torpedo tubes.

Protection.—Complete steel protective deck 2 inches thick, rising one foot above and sloping to 3 feet below the water line; 5-inch inclined armor over top of cylinders on a teak backing of 7 inches. Conning tower, 3 inches.

Motive power.—Triple-expansion engines of 9,000 I. H. P., with forced draft, to give 19.5 knots speed; coal capacity, 400 tons.

Dimensions.—Length, 320 feet; beam, 49 feet 6 inches; mean draught, 19 feet; displacement, 4,360 tons.

Forte, sister ship to *Flora;* launched at Chatham December 12, 1893.

Hermione, sister ship to *Flora;* launched at Devonport November 7, 1893.

DRYAD, HAZARD, HALCYON, HARRIER, HUSSAR.

(Page 10, No. XI.)

Torpedo vessels, *Halcyon* type. (See *Halcyon*, under Steam Trials.)

The *Dryad* was launched at Chatham November 25, 1893; the *Hazard* at Pembroke April 3, 1894; and the *Halcyon*, *Harrier*, and *Hussar* at Devonport on April 6, February 20, and June 19, 1894, respectively.

MINTO.

Troopship for the Indian Government; launched at Birkenhead, March, 1894.

Armament.—Four 3-pounder R. F. G.

Motive power.—Triple-expansion engines.

Dimensions.—Length, 205 feet, 6 inches; extreme breadth, 31 feet 6 inches; her gross tonnage is 930.

The vessel, which was designed by Sir E. J. Reed, is built of steel, has a clipper stem, elliptical stern, and is rigged as a fore-and-aft schooner.

STEAM TRIALS.

The acceptance trials for new machinery comprise an 8-hours' run at sea with natural draft, and one of 4 hours with forced draft, during which the required horse-power must be maintained continuously for the full time specified for the particular trial. The speed of the vessel on these trials is taken from the reading of the patent log, but does not form a necessary part of the acceptance trial.

For speed trials vessels are run over a measured-mile course, of which several are laid off at convenient places, the mean speed of not less than three consecutive runs being taken. No attempt is made to measure the speed by the number of revolutions of the propeller, nor is the speed measured on extensive runs. These speed trials are not exacted from all vessels previous to acceptance from the contractors. In his "Notes on recent experiences with some of Her Majesty's ships," read at the thirty-third session of the Institution of Naval Architects, Mr. W. H. White, the director of naval construction, referring to the vessels of the naval-defense act, said:

One vessel at least of each class has been tried at the deep-load line for speed. All the vessels tried have been subjected to the 8-hours' and 4-hours' trials for devel-

opment of power specified in the contract. It was obviously not worth while to multiply speed trials at the deep draught and to incur the expense and delay of ballasting since the test in typical vessels of the expenditure of power at various speeds gave all necessary information for the class.

In order to insure that the machinery of vessels in commission is kept in efficient order and to give opportunities of training the engine-room complement in working engines at high speed, a trial is to be made once in a quarter, consisting of a passage of not less than 24 hours' duration, to be run whenever circumstances will permit "with dispatch," or three-fifths the authorized power with natural draft. Should the power developed fall below this an explanatory report is required.

During each passage trial the engines are to be run for a period of 4 hours at their highest speed with natural draft, but the horse power developed is not to exceed the authorized natural-draft power.

The latest regulations concerning the speed to be used on different occasions order the following classification:

(*a.*) The authorized power with natural draft, equals the unit.

(*b.*) "With all dispatch" (the maximum power attainable for 24 hours) equals four-fifths the unit.

(*c.*) "With dispatch" (the maximum sea-going speed while the coal lasts), equals three-fifths the unit.

(*d.*) "With moderate dispatch," equals two-fifths the unit.

(*e.*) "Ordinary speed" equals one-fifth the unit.

(*f.*) "Most economical speed" equals as determined by trial and in accordance with the varying conditions of wind and weather.

The authorized power with natural draft (*a*) is to be used only during 4 hours of the quarterly passage trial mentioned above and in an emergency; the air pressure to be used is not to exceed half an inch of water for cylindrical boilers, and one inch for the locomotive boilers of torpedo vessels, except when the boilers are fitted with automatic ash-pit doors, in which case these air pressures may be exceeded by one-quarter of an inch of water if necessary to obtain the power.

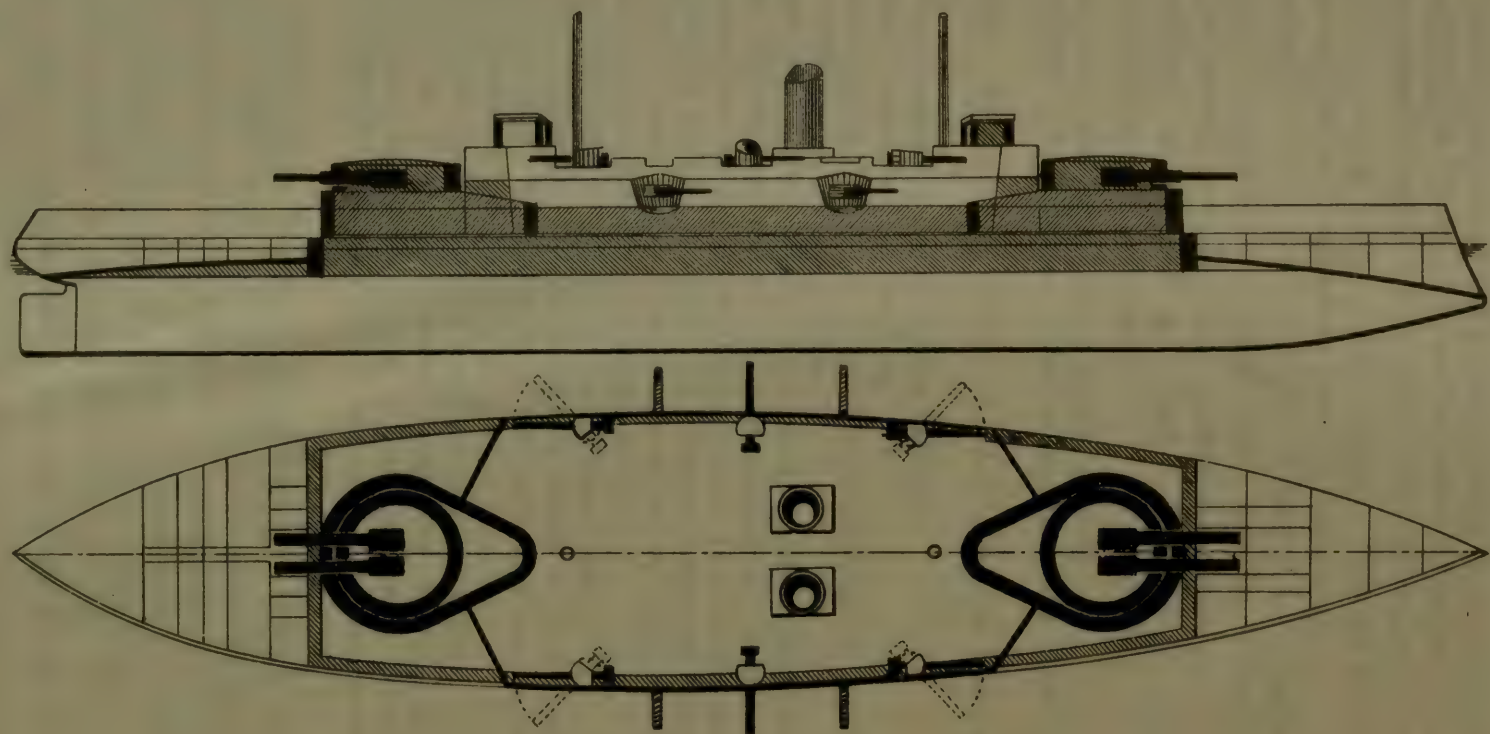
The four-fifths power (*b*) is only to be used in cases of great urgency.

When steaming "with dispatch" (*c*) all the boilers should be in use and the engine-room staff in 3 watches. When coal is worked back, assistance should be given from the deck if the work cannot be properly done without it.

"Ordinary speed" (*e*) is the speed at which passages are ordinarily to be made, but should be superseded by the "most economical speed" (*f*) when it is required to steam the greatest distance for a given amount of coal. The latter should also be used in those cases where the ordinary speed is less than the most economical speed.

An order has recently been issued by the Admiralty that in future the captain of each vessel is to take the earliest opportunity, when engaged on ordinary service in calm weather, of ascertaining the most economical speed of the ship—that is to say, the speed at which the greatest distance can be run per ton of coal per hour. For this purpose the engines are to be worked at different rates of speed for at least 6 hours at each rate, and the consumption of coal in hundredweights per hour, the speed of the vessel, distance run per ton of coal, and the average indicated horse power developed are to be carefully calculated and inserted in the engine-room log. This method is to take the place of what is known as "Admiral Ryder's diagram," heretofore employed.

H.M.S. HOOD.



THE ENGINEER.

ROYAL SOVEREIGN, RESOLUTION, EMPRESS OF INDIA, REPULSE, HOOD, RAMILLIES, REVENGE, ROYAL OAK.

[Page 334, No. VIII; 13, No. IX; 13, No. X; 12 and 15, No. XI; 152, No. XII.]

The results of the steam trials of the 8 battleships of the *Royal Sovereign* type show a considerable variation both in the speed attained and in the horse power developed. The dimensions of the vessels and the motive power are practically alike, no great variations having been made in the design, while none of them experienced exceptional weather during the trials.

The *Royal Sovereign*, the first one completed, is the only one from which the test for the full 13,000 I. H. P. was exacted (p. 16, No. XI), the conclusion that the boilers could not withstand the air pressure necessary to develop that power having led the Admiralty to determine that 11,000 I. H. P. should be regarded as sufficient for the remainder of the class.

A considerable departure from the designed load draught of the vessels was a feature of the trials and renders difficult a just conclusion as to the relative merits of the class. The *Royal Sovereign* was loaded to her full designed draught, while the *Repulse* had 2,000 tons less displacement, the *Empress of India*, 1,000 tons less, and the others were in all cases considerably below the load draught when tried.

Ships.	Draught.				Displacement at trial.	Indicated horse power.		Speed by log.	
	Forward.		Aft.			Natural draft.	Forced draft.	Natural draft.	Forced draft.
	Ft.	*In.*	*Ft.*	*In.*					
Royal Sovereign	27	0	28	0	14,260	9,661	.....	16.375	.....
	26	8	28	0	14,150	.....	13,363	.....	18
Empress of India	25	4	26	4	13,210	9,508	.....	15.25	.....
	24	11	25	9	11,625	.....	.....	.....	18
Repulse	22	5	25	9	12,100	9,588	.....	17.78	.....
	22	5	25	9	12,100	.....	11,315	.....	18.2
Hood	25	6	27	4	13,580	9,539	.....	15.75	.....
	25	3	27	4	13,500	.....	11,446	.....	16.9
Ramillies	24	3	26	1	12,800	9,443	.....	16.75	.....
	24	3	26	1	12,800	.....	11,571	.....	17.25
Resolution	24	4	25	9	12,730	9,248	.....	16.73	.....
	23	10	25	8	12,530	.....	11,401	.....	17.92
Revenge	24	2	25	9	12,680	9,177	.....	17.375	.....
	24	1	25	8	12,610	.....	11,524	.....	17.5
Royal Oak	24	6	25	6	12,690	9,221	.....	16.5	.....
	24	4	25	5	12,610	.....	11,571	.....	18.27

A natural-draft sea-trial of the *Royal Sovereign* was made in October, 1893, the object being to test the durability of the cap ferrules fitted to the boiler tubes. The run was made from Eddystone to Gibraltar and lasted seventy hours. Fair weather was carried as far as St. Vincent, during which a speed of 15.2 to 15.5 knots an hour was realized. The

wind then came out strong and ahead, increasing to a three-quarters gale, which only retarded the vessel to 14.5 knots, although the seas were heavy. The boilers worked very well throughout the trial.

The commissioning trial of the *Ramillies* took place on October 28, 1893, in a strong head wind and moderate sea. The power developed varied from 8,887 to 9,900, with a mean for the 3 hours of 9,400 and a corresponding mean speed of 14 knots.

The *Resolution* is one of the eight battle ships of the *Royal Sovereign* type built under the naval-defense act. With the exception of the *Hood*, which has turrets where the others have barbettes, the vessels are alike in all the important details. The following description may, therefore, apply to all:

The vessel is constructed entirely of steel, the stem, stern post, rudder and struts being of cast steel. A double bottom extends throughout the engine room, boiler, and main magazine spaces. The engines and boilers are separated by water-tight bulkheads, and numerous bulkheads at the sides form the coal bunkers and wing spaces. On the platform, débris, and lower decks is placed the auxiliary machinery, including steering engines, electric engines, and hydraulic pumping engines, and there is also a fully equipped workshop, besides numerous storerooms.

The upper deck is flush, and above it are the shelter decks, on which are the conning towers, two in number, surmounted by a flying bridge, and connected with each other by a fore and aft bridge.

There are 2 smoke pipes placed on the same athwart-ship line, and 2 masts fitted with military and signaling tops. There are 21 boats, which are stored amidships, and include two 56-foot torpedo boats. A strong steel derrick is fitted to the main mast for lifting them, and another is fitted to the foremast for working those of a lighter description.

Armament.—Four 13.5-inch 67-ton B. L., in pairs, in barbettes forward and aft on the central line, with an arc of fire of 240 degrees. Ten 6-inch R. F. G., four in armored casemates on the main deck, with arc of fire of 120 degrees, and six on the upper deck in sponsons. Sixteen 6-pounder R. F. G., of which four are on the upper deck and twelve on the main deck. Nine 3-pounder R. F. G., of which three are in the tops. Two 9-pounder field guns and eight 45-inch-caliber five-barrel machine guns. Seven torpedo tubes, of which two, with under-water discharge, are in the bow, four in broadside between armored screens, and one in the stern, fixed, with over-water discharge. The total weight of the main armament is 1,410 tons; weight of fire ahead and astern 2,700 pounds; abeam, 5,500 pounds. There are also four projectors of 25,000 candle power each, worked by a dynamo under the protective deck. The vessels of the *Royal Sovereign* type can throw in four minutes 720 projectiles, capable of piercing an unarmored side. Of these

576 can be kept out by 4 inches of steel; 10-inch steel is proof against 716, all but 4; against these probably no vertical armor is proof.

Protection.—Partial, compound water-line belt about 250 feet long and 8 feet 6 inches wide. At the waist it is 18 inches thick, decreasing to 8 inches below water. The belt tapers at the ends to 14 and 6 inches, while between the ends and the waist it is 16 to 7 inches thick. The transverse bulkheads at the ends of the belt are 16 and 7 inches thick forward, and 14 to 6 aft. A side-armor nickel-steel belt about 9 feet 6 inches wide extends for about 144 feet, with a thickness of 4 inches. The main deck casemates are 6 inches thick in front and 2 on side and rear. Screen bulkheads, 3 inches. The forward conning tower is 14 inches and the after one 13 inches thick; ammunition tubes, 8 and 3 inches.

The 13.5-inch guns are carried in pear-shaped barbettes which rise from the protective deck (*see* plate, p. 12, No. XI), 54 feet 1 inch long, with a greatest width of 38 feet 2 inches, decreasing to 6 feet, the smaller end containing the ammunition hoist.

The protective deck is of steel, 3 inches thick over the belt armor, and the under-water deck is 2.5 inches forward and abaft the belt, extending to the ends.

The shields for the 6-inch guns on the upper deck are 4 inches thick. The armor belt is backed with from 4 to 8 inches of teak, and there is about 10 feet of coal protection over the machinery and boilers.

Motive power.—Triple-expansion engines with cylinders 40, 59, and 88 inches in diameter and a stroke of 51 inches. There are 8 single-ended boilers, each 15 feet 6 inches in diameter by 9 feet 6 inches long, with 4 furnaces to each and designed for a working pressure of 155 pounds. There are in all no less than 69 auxiliary engines. The engines were designed to develop with forced draft 13,000 I. H. P., giving a speed of 17.5 knots, and with natural draft 9,000 I. H. P. and speed 16 knots.

The Admiralty have recently directed that in the battle ships of the *Royal Sovereign* class the wing spaces abreast the coal bunkers proper are to be used as auxiliary bunkers, and the full stowage of coal is always to be taken on board when the ships are coaled. This will increase the coal capacity from 900 to 1,450 tons, and besides affording a greater coal protection will increase the steaming radius from 5,000 to 8,055 knots, at 10 knots speed.

To prevent any chance of mishap in the bunkers through the accumulation of gases, due to long confinement of the coal in the bunkers, it is ordered that the coal be not allowed to remain in the wings for long periods, but is to be worked out from them as well as from the ordinary bunkers.

Dimensions.—Length on load-water line, 380 feet; extreme breadth of beam, 75 feet; mean draught, 27 feet 6 inches; displacement, 14,150 tons; coal capacity at load-water line, 900 tons.

The complement of the *Resolution* is 725 officers and men.

The time taken to complete the vessel from the date of her launch was only thirteen months, which fact is noteworthy as surpassing the record of any private firm heretofore.

The *Resolution*, convoying the *Gleaner*, torpedo vessel, started for Gibraltar in December, 1893, but, encountering a gale, was compelled to return to port after having shipped large quantities of water and made very heavy weather of it. The excessive rolling of the ship, which is characteristic of this type, and concerning which reports had been made from other vessels, caused the Admiralty to have bilge keels fitted to the *Repulse* as an experiment.

A series of careful observations made while the channel squadron was at anchor, recently, in Lough Swilly showed that the *Repulse* rolled only 1 degree while the *Royal Sovereign* and her sister ships were rolling from 5 to 8 degrees, and on a passage from the Hebrides, with a beam swell, the greatest roll of the *Repulse* was 11 degrees while the *Empress of India* rolled 28 degrees, the *Resolution* 24 degrees, and the *Royal Sovereign* 33 degrees. It has, therefore, been decided to order bilge keels for all the vessels of the *Royal Sovereign* type as they return to government yards.

In regard to the large quantities of water which entered the *Resolution*, and caused very much unfavorable comment, an officer on board stated that this was only due to lack of snugness in some of the fittings when the ship left the navy-yard. The 6-inch gun ports could not be closed tightly; a ventilator on the forecastle was not removed, owing to the plate having been lost, and eventually carried away, and the forward barbette was not properly covered. The entire damage done amounted to but very little. (*See* Chapter VIII.)

CENTURION, BARFLEUR.

(Page 334, No. VIII; 13, No. IX; 13, No. X; 12, No. XI, with plate; 152, No. XII.)

These battle ships of a smaller type than the *Royal Sovereign* type, just enumerated, have passed satisfactory trials with the following results:

		Draught.		Displacement.	I. H. P.	Speed by log.
		Forward.	Aft.			
Centurion	N. D	25.0	26.0	10,590	9.703	17.5
	F. D	25.0	26.0	10.590	13,174	18.51
Barfleur	N. D	21.6	25.6	9.500	9,934	17.165
	F. D	22.0	25.6	9.650	13,163	17.537

The *Barfleur*, as compared with most battle ships of her size, is of light draught and will be able to pass through the Suez Canal with a large quantity of coal on board. She is wood-sheathed and coppered and is particularly adapted for service on foreign stations. Relatively high speed was aimed at in the design and larger

and heavier boilers than are usually fitted in battle ships were provided, so as to enable her to steam continuously at good speed for long distances. She has two military masts, with light signal yards, and two smoke pipes placed side by side. Her freeboard forward is 21 feet, aft 20 feet. Service magazines are provided for each gun position, into which the ammunition is served from the magazines below. The midship section is very flat across the floor, and the double bottom extends right up to the armor shelf; the framing is very strong and arched stiffeners are placed behind the heavy and light armor, the coal bunkers being associated with these. The complement consists of 650 officers and men, of whom 122 are firemen.

Armament.—Four 10-inch, 29-ton B. L., 25 feet above the water-line in two barbette turrets on the center line. They can be fired on either broadside. Ten 4.7-inch R. F. G. in broadside, of which six are on the upper deck between the barbettes and four are in sponsons on the main deck, 14 feet above the water-line. Eight 6-pounder and nine 3-pounder R. F. G., and seven machine guns. There are seven torpedo tubes, of which two are in the bow, with under-water discharge, one in the stern, and four in broadside behind light armor with over-water discharge. Four search lights.

Protection.—A water-line belt of compound armor, with a maximum thickness of 12 inches, extends for about 200 feet. It is associated with an armored deck 2 to 2.5 inches thick, and completed at the extremities by bulkheads 8 inches thick, forward and aft of which the protective deck extends to the bow and stern respectively. The broadside above the belt, to the height of about 9 feet above the water, is protected by 4 inches of nickel-steel, while the casemates of the four R. F. G., on the main deck are 2 inches thick, of the same material.

The redoubts in which the 10-inch guns are placed are designed to combine, as far as possible, the advantages of both turret and barbette, the special features being: (1) high angle fire, allowing an elevation of 35 degrees and a depression of 7 degrees; (2) the guns can be loaded while in any position; (3) they can be worked by hand.

The armor of the barbettes, which extends down to the protective deck, incloses the turntable on which the guns are placed, its roller path, and the latter's supports, as well as the revolving shell chamber and the greater part of the ammunition hoist.

The steam machinery of the ammunition hoist is placed below the barbette on the flat, or deck next below the protective deck.

The barbette armor, which arises from the protective deck, forms a cylinder 20 feet high, 26 feet in inside diameter, and 9 inches thick, of compound armor; within, and co-axial therewith, is a second cylinder somewhat smaller in diameter and about 14 feet high, comprising the support of the roller path, upon which rests the turntable bearing the guns; a third cylinder, 4 feet 3 inches in diameter, includes the ammunition hoist. The mechanism upon which the working of the guns

depends is, therefore, not supported by the barbette armor, this being a main feature of the design, for the armor of the barbette is not likely to be indented to the extent of injuring the working parts, as might be the case were they supported by it.

The guns are protected by a 6-inch nickel-steel shield, which revolves with the turntable; the approximate total weight of each position, including the 2 guns, 20 men, and 60 rounds of ammunition, is about 210 tons.

As an alternative for the steam engine on the platform deck for revolving the turret, a training winch is provided with hand-turning cranks, giving room for 12 men to work at once. Steam is also used for the ammunition hoists, but hand power can be employed.

In the forward barbette, electric gear has been fitted to one of the guns for hoisting the charge from the shell chamber beneath the gun platform to the breech, and also for elevating the guns. The motors are placed on the platform and are protected by the barbette armor; they can be disconnected if desired and are water-tight, so that in case of a sea breaking over the turret short circuiting is avoided. This is the first vessel in the English service in which electricity has been applied in this way.

The hoods which protect the guns are entirely open in the rear; this would seem a bad feature, as in case of an engagement with two enemies, one on each beam, the breeches of the guns and the guns themselves would be entirely exposed.

Motive power.—Triple-expansion engines, driving twin screws, and designed to develop 9,000 I. H. P. under natural draft and 13,000 with forced draft. Eight steel boilers.

Coal capacity, 750 to 1,125 tons, with a corresponding steaming radius of 6,500 to 9,750 miles.

During her trials with natural draft the maximum horse power developed during one hour was 10,615, while 10,070 horse power was indicated for two consecutive hours with open fire-rooms. With forced draft of 1.4 inches air pressure, the contract horse power for the four hours was exceeded by 163.

Dimensions.—Length on load water line, 360 feet; extreme breadth of beam, 70 feet; mean draught at L. W. L., 25 feet 6 inches; displacement, 10,500 tons.

DEVASTATION.

(Page 20, No. X.)

The trials of the battle ship *Devastation* after her refit resulted satisfactorily, the engines working with great smoothness and uniformity. The contract requirements were more than satisfied, and it was not deemed necessary to test the engines beyond that power.

	Natural draft.	Forced draft.
I. H. P.	6,000	7,214
Speed ... knots	13.25	14.56
Revolutions, mean	93.8	102.5
Boiler pressure ... pounds	140	141.6
Vacuum ... inches	28.3	28.4
Air pressure ... do	.50	1.03
Mean draught	25′ 10″	.....

The *Devastation* is the earliest of the seagoing turret-ships, and has just undergone a thorough reconstruction in hull, machinery, and armament. The central internal portion of the hull was rebuilt, involving a rearrangement of the water-tight subdivisions, the building of additional coal bunkers, and other extensive alterations. A military top has been added to her mast and provided with a couple of 3-pounder R. F. G. The electrical equipment has been brought up to modern requirements, including firing gear, search lights, and sub-marine torpedo apparatus, and helm signals have been provided in conjunction with entirely new steering apparatus.

The armament now consists of four 10-inch 29-ton B. L., two 7-pounder guns, six 6-pounder and eight 3-pounder R. F. G., and five 5-barrel Gardners. There are also two underwater torpedo tubes in broadside, with an allowance of twelve 14-inch Whitehead torpedoes. The original turrets have been utilized for the mounting of the 10-inch B. L., workable by hand as well as by machinery. The guns, however, protrude farther out of the turret ports than the old weapons did, so that, to counteract the distribution of weight, 200 projectiles will be stored on the opposite side of the turret.

HERCULES.

(Page 16, No. XI.)

The battle ship *Hercules*, after being refitted with triple-expansion engines of modern type designed to develop 8,500 I. H. P. with forced draft and 7,000 with natural draft, and a 4-bladed propeller in place of the former 2-bladed one, underwent a series of steam trials which, as far as power and speed are concerned, were satisfactory; the vibration, however, was found to be so excessive as to threaten to strain the vessel materially. No appreciable reduction in vibration was noticed on a second trial after the diameter of the propeller had been reduced by cutting off one inch from each blade. Two of the blades were then removed and the pitch reduced by one foot, making it 16 feet 6 inches, but the noise and vibration still continued to render her almost uninhabitable. Eventually a 4-bladed modified Griffith propeller, with an outward bend to the blades, set 6 inches farther to the rear and having a diameter of 21 feet .5 inch and a pitch of 17 feet 7.5 inches, was tried with satisfactory results.

The I. H. P. developed was as follows:

Revolutions.	I. H. P.	Revolutions.	I. H. P.
60	2,187	80	5,222
70	3,258	82 Speed by patent log, 13.2 knots	5,470
75	4,036	90 " " " " 14.8 "	7,685

The *Hercules* was originally completed and commissioned in 1868. Her main armament has not been changed, but she has been given in addition a number of 4.7-inch and other R. F. G.

NORTHUMBERLAND.

The battle ship *Northumberland*, after being refitted and provided with an entirely new set of boilers, was given a four hours' trial on May 18, with the following satisfactory results:

I. H. P	4281
Speed, knots	13.3
Revolutions, mean	48.3
Boiler pressure, pounds	31
Vacuum, inches	25.7

The vessel, which was built in 1861, has also been fitted with torpedo tubes, which were likewise successfully tested on the same day.

RUPERT.

(Page 10, No. IX.)

The steam trials of the coast-defense vessel *Rupert*, which has been reconstructed and fitted with new boilers and triple-expansion engines, designed to develop 6,000 I. H. P. with forced draft and 4,500 with natural draft, resulted as follows:

	Natural draft.	Forced draft.
I. H. P	4,857.65	6,025.61
Speed ... knots	13.75	14.4
Revolutions mean	105.5	111.68
Boiler pressure ... pounds	131	131
Vacuum ... inches	28.4	27.5
Air pressure ... do	.35	1
Mean draught	20′ 2″	19′ 9″

The *Rupert* has also been rearmed with two 9.2-inch and two 6-inch B. L., and ten R. F. G.

AGAMEMNON.

This vessel, which has been refitted, underwent satisfactory trials of her machinery off Plymouth in October, 1893.

AURORA.

(Page 310, No. VIII.).

The armored cruiser *Aurora*, which developed defects in her machinery while serving in the channel squadron, having undergone extensive repairs and alterations at the dockyard, was tried in September, 1892, with satisfactory results. I. H. P., 6,173; speed, 16 knots; revolutions, 103; boiler pressure, 127; vacuum, 23.8; air pressure, 0.22.

EDGAR, HAWKE, ROYAL ARTHUR, ENDYMION, CRESCENT, GRAFTON, GIBRALTAR, THESEUS, ST. GEORGE.

(Page 334, No. VIII; 14, No. IX; 14, No. X; and 13 and 18, No. XI.)

The nine first-class protected cruisers of the naval defense act have been completed and subjected to their trials. Forced draft, however, has been exacted from only the *Edgar* (p. 19, No. XI) and *Grafton*, as owing to the trouble experienced with boiler tubes under strong forced draft, the Admiralty decided to accept the machinery on its developing the guaranteed natural-draft power (10,000).

The following table gives the results of the trials of the class:

	Date.	Draught.	I. H. P.	Speed.	Revolutions.	Boiler pressure.	Vacuum.	Air pressure.
		Ft. In.						
Edgar	Nov., 1891	.....	10,200	19.25	.....	.....	.....	.....
		.....	[1]12,550	20.97	.....	.....	.....	.....
Hawke	Mar., 1892	.....	10,761	19.5	98.46	.....	.....	.3
		.....	12,521	20	102.18	.....	.....	.44
Royal Arthur	Nov., 1892	.....	10,062	18.22	100	146.6	27	.44
Endymion	May, 1893	20 7	10,646	20.9	99.5	152	27	.....
Crescent	do	24 7	10,370	18.6	98	152	.....	.....
Grafton	June, 1893	23 7	10,957	20.5	101.6	148	26.7	1.16
			[1]13,484	19.5	96	154	27	.41
Gibraltar	do	21 5	10,553	20.4	105.5	157	27	.15
Theseus	Dec., 1893	23 4	10,608	18.66	96.2	149.4	27.1	.....
St. George	Jan., 1894	21 3	10,536	20.2	105	153.8	27.7	.09

[1] Forced draft.

The commissioning trial of the *Edgar*, March 23, 1893, resulted as follows: I. H. P., 10,405; speed, 18.5; revolutions, 95.9; steam pressure, 144 pounds; vacuum, 27.2; air pressure, .5 inch.

The *Theseus* was built at the yards of the Thames Iron Works and Shipbuilding Company, Blackwall, and in common with the rest of her type was designed by Mr. W. H. White. These vessels of which the first, the *Edgar*, was launched in November, 1890, are similar to the *Blake* and *Blenheim* (p. 15, No. X; 17, No. XI), but somewhat smaller. They are flush-deck ships, having a freeboard forward of about 18 feet 6 inches, except in the cases of the *Royal Arthur* and *Crescent*, which have been given a top-gallant forecastle about 110 feet long, increasing the freeboard to 25 feet 6 inches, but necessitating thereby a reduc-

tion in weight of battery by the substitution for the forward 9.2-inch gun of two 6-inch R. F. G. in the vessels named.

The *Theseus* has a ram bow, 2 smoke-pipes and 2 pole masts, of which the main supports a large steel derrick for hoisting the boats, 15 being carried, including a 56-foot torpedo boat. The ship is lighted by electricity, and has on the main deck 4 small towers for the search lights. She has steam steering gear by means of which the rudder can be shifted from hard over to hard over in thirty seconds, and which can itself be changed to hand gear in a very short time. There are in all 5 steering stations.

Particular care has been given to the ventilation of the ship, as well for the living spaces as for the storerooms, coal bunkers, and magazines. In order to secure a thorough circulation of air, and yet avoid large openings in the magazine, a ventilating box, connected with the main trunk and provided with a valve that can easily be closed, is fitted to the magazine. A pipe leads from the upper deck to the ventilating box, at the bottom of which rests a ball; in case of an alarm of fire it would be the duty of the person stationed for the purpose, to pour water down the pipe, thus causing the ball to float upwards until it closes the airway, open under ordinary circumstances, and thus prevent sparks from being carried into the magazine by the ventilating current.

Armament.—Two 9.2-inch 22-ton B. L.; ten 6-inch R. F. G.; eight 6-pounder, eight 3-pounder R. F. G.; two 9-pounder field guns, and five machine guns. The 9.2-inch guns are mounted on V. C. P. mounts in the bow and stern; they have an arc of fire of 240 degrees, and are protected by 2.5-inch steel shields. The ten 6-inch R. F. G. are in broadside, six on the upper deck under 3-inch shields and four on the main deck in casemates. Four torpedo tubes, two, fixed, with under-water discharge, forward, and two in broadside with over-water discharge.

Protection.—Complete steel protective deck 5 inches in maximum thickness; tops of cylinders protected by a 6-inch steel cupola, backed by 3 inches of teak. The main deck casemates are from 2 to 6 inches thick; conning tower, 12 inches; ammunition tubes, 7 inches.

Motive power.—Two inverted, vertical triple-expansion engines, designed to develop with forced draft 12,000 I. H. P., having cylinders 40, 59, and 88 inches in diameter with a stroke of 21 inches; eight single-ended boilers, each 16 feet 2 inches in diameter and 9 feet 10 inches long, with three furnaces to each boiler; total grate surface, 855 square feet; total heating surface, 21,400 square feet. The working pressure is 155 pounds per square inch.

The bunker capacity is 850 tons, but this can be increased by use of the wing passages to over 1,000 tons.

Dimensions.—Length, 360 feet; beam, 60 feet; mean draught, 23 feet 9 inches; the displacement at this draught being 7,391 tons.

ASTRÆA, BONAVENTURE, CAMBRIAN, CHARYBDIS.

(Page 14, No. IX; 14, No. X; 153, No. XII).

The steam trials of the *Astræa* type of cruisers resulted as follows:

NATURAL-DRAFT TRIALS.

	I. H. P.	Speed.	Revolutions.	Boiler pressure.	Vacuum.	Air pressure.
Astræa	7,600	19	130.7	147	27.1	.44
Bonaventure	7,340	19.2	133	149	26.8	.44
Cambrian	7,150	19.4	.....	.....	.....	.....
Charybdis	7,109.3	19.3	127.7	141.7	27.2	.57
Hermione	7,393	19	128.7	140	26.3	.45

FORCED-DRAFT TRIALS.

Astræa	9,112	19.75	138.3	149	24.7	1.44
Bonaventure	9,279	20	149.7	146	26.3	.87
Cambrian	9,176	20.8	.....	.....	.....	.....
Charybdis	9,136	20.5	.....	.....	.....	.....
Hermione	9,264	19.5	137.4	144	26.8	.94

The *Astræa* type of protected cruisers, of which 8 have been built, are improvements on the *Apollo* type, described on page 31, and are wood-sheathed and coppered. They are 20 feet longer than the *Apollos* and have 5 feet 10 inches more beam; the draught is more by 2 feet 6 inches and the displacement is 760 tons greater. They carry two more 4.7-inch R. F. G., having 8 where the others have 6, but in other respects the armament is the same.

INTREPID, IPHIGENIA, SAPPHO, BRILLIANT, ÆOLUS, RETRIBUTION, SCYLLA.

(Page 14, No. IX; 16, No. X; 22, No. XI.)

The remaining vessels of the *Apollo* type, protected cruisers, second class, have had their trials, which in every case have resulted successfully, although delays were caused in several instances by reason of leaky boiler tubes and overheating of machinery.

NATURAL-DRAFT TRIALS.

	Draught.	I. H. P.	Speed.	Revolutions.	Boiler pressure.	Vacuum.	Air pressure.
	Ft. In.						
Intrepid	.....	7,219	19.02	128	.....	27	.31
Sappho	15 9	7,301	19.41	129	137	27.5	.3
Iphigenia	16 9	7,215	19.25	129	151.5	26.9	.....
Brilliant	16 9	7,512	19.2	133.3	147.8	26	.16
Æolus	.....	7,458	19	132.6	150	27.8	.....
Retribution	.....	7,645	19	128.8	144.1	28	.....
Scylla	15 4	7,622	19.875	.....	.....	.....	.....

FORCED-DRAFT TRIALS.

	I. H. P.	Speed.	Revolutions.	Boiler pressure.	Vacuum.	Air pressure.
Intrepid	9,471	20.9	139	147	26.2	1.22
Sappho	9,617	20.47	140.3	142.6	27.7	.7
Iphigenia	9,302	20	138	150	26	.85
Brilliant	9,163.6	20.4	142.1	146.7	25.5	1.1
Æolus	9,255	19.5	143	150	27	.8
Retribution	9,367	.....	138.8	148	28	.61
Scylla	9,280	20.625	138.6	145	27.5	.87

Iphigenia.—The first natural-draft trial, August 12, 1892, had to be discontinued, owing to the giving out of the boilers at the end of the sixth hour. On the subsequent trials on September 22, after the boilers had been fitted with the Admiralty ferrule, the contract power was greatly exceeded, and on the forced-draft trial, on September 27, a maximum indicated horse power of 10,016 was developed, the speed on one run on the measured mile being 22 knots.

Intrepid.—The forced-draft trial which in May, 1892 (table p. 22, No. XI), had to be abandoned on account of hot bearings, was run in August with very satisfactory results.

Brilliant.—After the first natural-draft trial, when the contracted horse power was exceeded, the gudgeon pins were found to be fractured and the vessel remained in dock-yard hands for a considerable time. The subsequent trials were entirely successful, although, owing to the inferior quality of the coal used, a higher air pressure was found necessary than on the trials of her sister ship *Sybille.*

Retribution.—After her successful trials a crack was discovered in one of the furnaces, similar to the one which developed in the sister ship *Pique.* The furnace was repaired by the contractors and accepted conditionally, but during the naval manœuvres of 1893 it gave out again.

Sybille.—The furnaces of this vessel have given continuous trouble, having developed defects again and again since her delivery by the contractors in March, 1892. After a number of unsuccessful attempts to repair them the Admiralty have recently entered into a contract with a Newcastle firm for a new set of boilers and machinery.

Barham (p. 19, No. X).—This vessel, which failed to develop the designed horse power on her original trials, but which was nevertheless accepted, was, after undergoing certain alterations, including the ferruling of the boiler tubes, subjected to a series of experimental trials in the hope of reaching the power contracted for. The vessel has been severely criticised, both as to structural strength and boiler design, and although commissioned and now in service, has never proved satisfactory, her natural-draft power being given in the latest Navy List as 3,200 and forced-draft power "not yet settled."

After her failure in February, 1893, due to the breakdown of the fans producing the forced draft to the fire room, her trial in April resulted as follows: I. H. P., 4,538; revolutions, 193; boiler pressure, 137 pounds; air pressure, 2.1 inches. The speed on the measured mile was 18,645 knots, and the mean speed for three hours 20 knots.

The *Apollo* type was designed as an improvement on the *Medea* type (p. 337, No. VIII; 20, No. IX), and 29 of this type were included in the naval defense act. Eight of these were subsequently ordered enlarged to 4,360 tons and gave rise to the *Astræa* type.

The vessels are protected cruisers, with ram bows, built of steel, with stem, stern post, rudder, and shaft brackets of phosphor bronze, and are sheathed with wood and coppered. They have 2 smoke-pipes and 2 pole masts with light fore and aft rig. There is a large number of water-tight compartments and the double bottom extends the full length of the engine and boiler space, its continuity being carried forward and aft by the water-tight flats forming the shell rooms, magazines, and storerooms. The bunkers are placed alongside the engines and boilers and extend to the upper deck. There is a complete installation of electric-light plant.

Armament.—Two 6-inch R. F. G., one mounted on the poop and one on the forecastle. The original battery included two 6-inch B. L., but a recent order of the Admiralty has directed the change to be made as the vessels return to home ports. Six 4.7-inch R. F. G., in broadside, eight 6-pounder, and one 3-pounder R. F. G., four 5-barrel Nordenfelt, and one 9-pounder field gun. There are 4 torpedo tubes with over-water discharges, one in the bow, one in the stern, fixed, and one, on training carriage, on each quarter, and three search lights.

Protection.—A steel protective deck, two inches thick on the sides and one inch on the crown, extends the entire length of the vessel, rising one foot above the water line at the center of the vessel, and sloping to four feet below the water line at the sides. The tops of the cylinders are protected by five inches of inclined steel armor, backed by seven inches of teak, and coal protection is afforded by the bunkers. The conning tower on the after end of the forecastle is three inches thick.

Motive power.—The engines are vertical, triple-expansion, with cylinders 33.5, 49, and 74 inches in diameter, and a stroke of 39 inches, designed to develop 7,000 I. H. P. with natural draft and 9,000 with forced draft, the latter being supplied by fans and closed fire rooms.

The boilers are 5 in number, 3 being cylindrical, double ended with 6 furnaces each, and 2 single ended with separate combustion chambers, and 3 furnaces each. The total grate surface is 595 square feet; total heating surface about 15,800 square feet; working pressure, 155 pounds.

With a draught of 17 feet 6 inches the coal capacity is given at about 400 tons, making the steaming radius at maximum speed 1,000 knots, and at 10 knots 8,000.

Dimensions.—Length on load-water line, 300 feet; extreme breadth of beam, 43 feet; maximum draught, 17 feet 6 inches; displacement, 3,600 tons, the latter figures varying slightly in the different vessels of the type.

The complement is about 250 officers and men.

Several of the vessels of the *Apollo* type have shown evidences of structural weakness when steaming at high rates of speed, the vibration in the case of the *Pique* being so great as to buckle some of the frames, necessitating the introduction of stiffeners. An examination of all the vessels of the class was ordered by the Admiralty in order that they might, if necessary, be stiffened before going into active service.

The changes from 6-inch B. L. to 6-inch R. F. G. have been made in most of the vessels of that type.

These vessels are to be provided with shelter houses on the bridge for the protection of the helmsmen.

CIRCE, LEDA, HEBE, ANTELOPE, ALARM, JASON, NIGER, JASEUR, ONYX, RENARD, SPEEDY.

(Page 15, No. IX; 10, No. XI; 153, No. XII.)

The trials of these torpedo vessels, enlargements of and improvements on the *Sharpshooter* type, have, as a rule, been very successful, only minor accidents in a few cases necessitating a second forced-draft trial.

The duration of the forced-draft trial for torpedo vessels is three hours.

Name.	Built at—	Engined by—	Forced draft.		Natural draft.	
			I. H. P.	Speed.	I. H. P.	Speed.
Circe	Sheerness	Penn	3,508	19.66	2,618	18.27
Leda	do	do	3,597	18.3	2,691	17.75
Hebe	do	Dockyd	3,566	19	2,702	17.8
Antelope	Devonport	Yarrow	3,621	19	2,630	17.25
Alarm	Sheerness	Penn	3,886	19.2	2,593	18
Jason	Barrow	N. C. and A. Co.	3,552	19	2,676	19
Niger	do	do	3,786	19.3	2,701.8	17.5
Jaseur	do	do	3,711	19		
Onyx	Birkenhead	Laird	3,548	19	2,531	17.5
Renard	do	do	3,962	19.4	2,583.6	17.6
Speedy	Chiswick	Thornycroft	4,703.2	20	3,046	18.5

The trials of the *Speedy*, which took place off Sheerness in the autumn of 1893, were of especial interest on account of the new type of boiler with which the vessel is fitted. In preparing for the final official forced-draft trial, which, after several mishaps, took place on November 7, 1893, steam was raised and run up to a pressure of 200 pounds in twenty minutes, although the boilers were fired by navy firemen with no previous knowledge of the Thornycroft boiler.

In general appearance the *Speedy* is somewhat peculiar, having three smoke-pipes and two pole masts, while from the stem there extends aft for about one-third of her length a raised forecastle deck which is about 7 feet above the main or upper deck; thence aft to within 60 feet of the stern is a flying bridge, the chief object of which is to give access to the different compartments in bad weather, when, on account of the low freeboard of the main deck (about 6 feet), it would be apt to have a good deal of water on it. The deck abaft the flying bridge is flush.

The machinery is in the central part of the vessel and is inclosed by bulkheads with water-tight doors, the bulkheads extending from the upper deck to the bottom plates, the forward one being at the place where the forecastle deck terminates; forward of it is a lower deck about 8 feet 6 inches above the floor, used as a berthing space for the crew. Beneath the berth deck the vessel is subdivided into numerous water-tight compartments forming the storerooms, magazines, torpedo room, etc. The lower deck, forward and abaft the machinery space, is water-tight, having coamings about all the openings, and water-tight hatches, forming practically a double bottom forward, when the hatches are closed. Amidships there is but a single skin under the machinery space.

Armament.—Two 4.7 inch R. F. G. protected by segmental shields, one mounted on the forecastle and the other aft. Four 3-pounder R. F. G. and three torpedo tubes with above-water discharge, one fixed in the bow and one on each side on training carriages. There is one search light.

Motive power.—Two sets of triple-expansion engines having cylinders 22, 34 and 51 inches in diameter, with a stroke of 21 inches, designed to run at 250 revolutions per minute with a pressure of 210 pounds per square inch. The boilers are 8 in number, of the Thornycroft water-tube type, each with 25.5 square feet of grate surface and 1,840 square feet of heating surface. The contract in the case of the *Speedy* called for 4,500 I. H. P., at which power the speed was calculated to be 20.25 knots. The total weight of the machinery and boilers, including water, is 211.3 tons.

The following are the particulars of the trials of the *Speedy*:

	Natural draft.	Forced draft.
I. H. P	3,046	4,703.2
Speed ..... knots	18.5	20
Revolutions, mean	206.4	245
Boiler pressure ..... pounds	183.3	193.6
Vacuum ..... inches	27.5	27.3
Air pressure ..... do	.....	1.7

After the vessel had been accepted and commissioned she was submitted to a series of experimental trials with very favorable results. With a mean boiler pressure of 177 pounds, the engines registering 207

revolutions per minute, a mean of 3,071.2 I. H. P. was developed with natural draft and a speed of 17 knots maintained.

HAZARD, HALCYON, DRYAD.

(Page 10, No. XI.)

The forced-draft trial of the *Hazard* took place on April 3, at which a mean I. H. P. of 3,714 was developed, with a corresponding speed of a little over 19 knots. This was in excess of the contract power, as was also the power developed on the natural-draft trial, 2,600, but, although both trials were deemed satisfactory, a subsequent examination of the boilers and machinery revealed certain important defects. The Admiralty decided to submit the vessel to another natural-draft trial before accepting the machinery, and this took place on June 7, 1894, with the following results:

I. H. P		2,620
Speed	knots	17.5
Revolutions, mean		228.9
Boiler pressure	pounds	125
Vacuum	inches	25
Air pressure	do	1.82

The estimated horse power and speed were both exceeded.

The natural-draft trial of the *Halcyon* on May 30 gave the following results:

I. H. P		2,590
Speed	knots	16.9
Revolutions, mean		227
Boiler pressure	pounds	147
Vacuum	inches	26.3
Air pressure	do	1.04

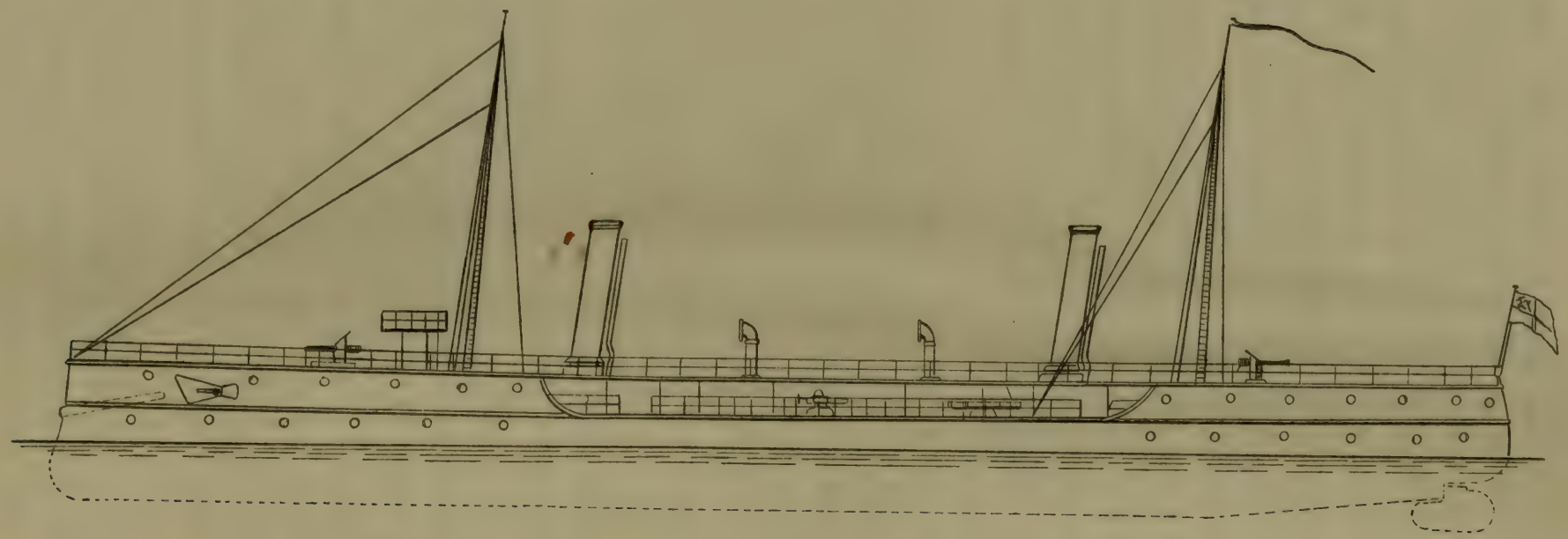
The 3 hours' forced-draft trial of the machinery of the *Halcyon* on June 7 was unsuccessful, for, after working for 25 minutes at 3,500 I. H. P., the main bearing bolts of the starboard engine gave way and the trial had to be stopped.

The steam trials of the *Dryad* took place on April 13 and 26, but although in each case the contract power was exceeded, the trials were unsatisfactory, owing to the leakage of the boiler tubes. The following results were obtained.

		Natural draft.	Forced draft.
I. H. P		2,696	3,709
Speed	knots		18.5
Revolutions, mean		213.8	242
Boiler pressure	pounds	134.6	149
Vacuum	inches	29.3	27.4
Air pressure	do	.96	2.28

On her subsequent trial on June 2 the results were satisfactory and the vessel was accepted.

DRYAD.



LE YACHT.

The *Halcyon* type of torpedo vessel is the outcome of a series of progressive steps in ship construction growing out of the demand for small, swift vessels of sea-keeping qualities to operate against the torpedo boats of an enemy approaching the coast, or to cruise with the fleet in home waters and the Mediterranean as scouts or dispatch vessels.

The first of the series was the *Rattlesnake*, laid down in 1885. She had a displacement of 550 tons and an indicated horse power on her trial of 2,718, which gave a speed of 18.8 knots as the mean of 6 runs over the measured-mile course. The vessels of this type had raised poops and forecastles, with a sunken well between, the rail being made continuous with the bulwarks in the midship part. They were severely criticized for the lightness of their construction, and when steaming in a sea-way, shipped great quantities of water and steered very badly on account of their light draught, although they were found safe enough when carefully handled. They were, moreover, considered too small for their purpose, and the *Sharpshooter* type was designed as an improvement, the displacement being increased to 735 tons.

In this type a high forecastle only was provided, the rest of the length being flush and having no bulwarks to hold the water shipped. Deck houses with a fore and aft bridge over them were placed inboard to permit of access to the machinery space when in a sea-way. They were originally designed for a speed of 21 knots, with a horse power of 4,500, but failing on the trials, owing to difficulties with the boilers, the required horse power was reduced to 3,500, the maximum speed realized under the most favorable conditions being 19.25 knots.

The experiences with the *Sharpshooters* were, however, very unsatisfactory; they were found to be structurally weak and proved themselves very poor sea boats.

The next advance produced the *Jason* type, the results of whose trials are given in the preceding table. Of these the *Speedy* already described, is the most remarkable, and although differing from all the others as regards her boilers, may in other respects be taken as representing the type, as all were built from the same design of Mr. W. H. White. The others have locomotive boilers and call for 3,500 I. H. P., with forced draught, and a speed of 19 knots.

A further advance in size led to the *Halcyon* type, comprising the 5 vessels now completing. They differ from their predecessors in having a poop in addition to the higher freeboard forward, giving the advantages of a steadier gun platform, better living quarters, improved seagoing qualities, and a greater ability to keep their speed in rough water, but resemble them in practically all other respects.

Armament.—Two 4.7 inch R. F. G., one on the forecastle and one abaft the mainmast, both with segmental shields; four 6-pounder R. F. G.; five torpedo tubes, one fixed, in the bow and twin tubes on each side, on training carriages.

Motive power.—Triple-expansion engines having cylinders 22, 34, and 51 inches in diameter, with a stroke of 21 inches, and designed to develop with forced draft, 3,500 I. H. P., and a corresponding speed of 19 knots. There are 4 locomotive boilers, having a total grate surface of 182 square feet, total heating surface 6,256 square feet, and working pressure of 155 pounds per square inch.

Coal capacity at load-water line 100 tons, which at 10 knots gives a steaming radius of 2,500 knots.

Dimensions.—Length on water line, 250 feet; extreme breadth of beam, 30 feet 6 inches; displacement, 1,070 tons; mean draught, 9 feet.

SHARPSHOOTER.

(Page 303, No. VII; 336, No. VIII; 22, No. IX; 27, No. X.)

A successful three hours' forced-draft trial of this vessel, which has been fitted with Belleville boilers, for experimental purposes, was made on May 29, resulting as follows:

I. H. P		3,238
Speed	knots	19
Revolutions, mean		254.7
Boiler pressure	pounds	183
Vacuum	inches	26.4
Air pressure	do	.13

The record of coal consumption was 2.04 per I. H. P. per hour, and it is stated that there would be no difficulty in attaining 3,500 horse power by slightly increasing the forced draft.

WARREN HASTINGS.

(Page 153, No. XII.)

The steam trials of this troop ship in June, 1893, resulted satisfactorily, both on the measured mile and on a 6-hours' deep-sea run. The I. H. P. developed was 3,500, and the speed, with 135 revolutions, 17 knots, being one knot in excess of the contract speed.

The vessel was built of steel, at Barrow, from the designs of Sir E. J. Reed, and has accommodations for 1,000 troops, 29 officers, and 6 ladies. Her principal characteristics are as follows:

Armament.—Six 3.9-inch R. F. G., six 3-pounder R. F. G., and four Nordenfelt machine guns.

Motive power.—Triple-expansion engines driving twin screws; the propellers are of Delta bronze, 13 feet 6 inches in diameter, with a pitch of 15 feet 3 inches.

Dimensions.—Length, 348 feet; breadth, 48 feet 10 inches; displacement, 4,500 tons.

MALABAR.

On a 6-hours' trial the Indian troop ship *Malabar*, after undergoing a series of repairs, developed 3,218 I. H. P., and a speed of 13 knots. The *Malabar* has had a number of trials, on one of which she developed 3,225 I. H. P., and a speed of 13.5 knots, but at its close her boiler tubes were leaking so badly as to necessitate extensive repairs.

VESSELS LOST OR STRUCK FROM THE LIST.

Victoria, battle ship, lost June, 1893; *Hector*, coast-defense vessel, ordered struck from the list of effective vessels.

Ordered sold: *Benbow*, wooden battle ship; *Euryalus* and *Bacchante*, unprotected cruisers; *Wolverine*, *Irresistible*, and *Eagle*, sloops; *Crocodile*, troop ship, *Gipsy*, cutter, and *Thisbe*, church ship.

Gunboats converted into coal hulks: *Firm*, *Forrester*, *Espoir*, *Goshawk*, and *Elk*.

TORPEDO BOATS.

The naval estimates for the present financial year appropriate the sum of $7,490,081 for 42 first-class torpedo boats of the *Havock* type, exclusive of armament and ordnance stores. This number includes those already enumerated on p. 150, No. XII, which were ordered last year in advance of the estimates and built out of money available as unexpended on other vessels with whose progress there was delay. The new building programme proposes to increase the whole number of these torpedo boats to 64 on the basis of four for each battle ship built for the channel and Mediterranean squadrons. Some minor changes have been made in the designs and a slight increase in size ordered, and each contractor has been allowed to furnish his own type of machinery and boilers, but as a whole the boats follow very closely the general features of the original of the type, the *Havock*, as designed by Mr. W. H. White.

BANSHEE, CONTEST, DRAGON, FERVENT, ZEPHYR, CONFLICT, HARDY, HAUGHTY, SPITFIRE, SWORDFISH, STURGEON, STARFISH, SKATE, SALMON, SNAPPER, SUNFISH, RANGER, OPOSSUM, HANDY, HART, HUNTER, ZEBRA.

The contracts for the additional boats have been awarded, as follows:

Banshee, *Contest*, *Dragon*, to Messrs. Laird Bros., Birkenhead; *Fervent*, *Zephyr*, to Messrs. Hanna, Donald and Wilson, Paisley; *Conflict*, to Mr. J. S. White, Cowes; *Hardy*, *Haughty*, to Messrs. William Doxford & Son, Sunderland; *Spitfire*, *Swordfish*, to Sir W. G. Armstrong, Mitchell & Co., Newcastle-upon-Tyne; *Sturgeon*, *Starfish*, *Skate*, to Naval Construction and Arms Company, Barrow; *Salmon*, *Snapper*, to Messrs. Earle, Hull; *Sunfish*, *Ranger*, *Opossum*, to Messrs. Hawthorn, Leslie & Co., Newcastle-upon-Tyne; *Handy*, *Hart*, *Hunter*, to Fairfield Shipbuilding Company, Glasgow; *Zebra*, to Thames Iron Works, Blackwall.

These boats are to be finished within twelve months from the date of the contracts, and have been allotted to the three fleet reserves as follows: Devonport, 12; Medway, 14; Portsmouth, 16.

Provision has also been made for 10 more torpedo boats of the first-class, to be built by contract. They are to be armed with three 3-pounder R. F. G., and the sum of $826,496 is to be expended upon them to March 31, 1895, exclusive of armament and ordnance stores.

The subject of torpedo boats has received most careful attention during the past year, especially in reference to the vessels of the *Havock* type, and the experiences with them have resulted in a number of orders from the Admiralty looking to an improvement of the boats and an amelioration of the condition of their crews.

The difficulty of obtaining access to the necessary compartments at a time when the water-tight doors are required to be instantaneously closed has led to an order directing that the bulkhead doors of all first-class torpedo boats be removed and the apertures so built up as to make the bulkheads water-tight. Hatchways with water-tight lids are to be fitted to those compartments to which access has formerly been obtained through a bulkhead door. Additional strength will thus be gained also.

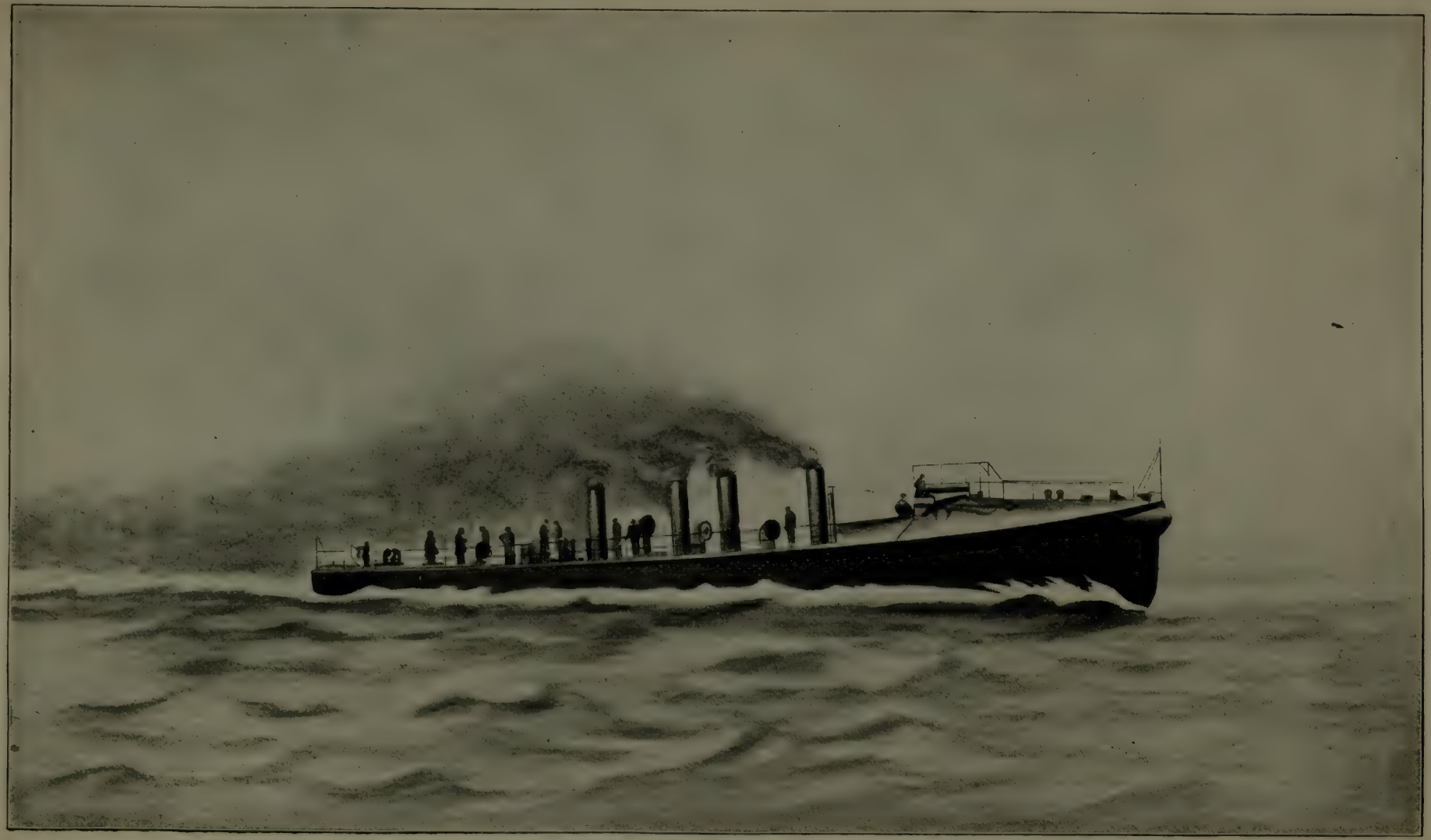
In order to permit temporary repairs being made in the event of accidents by collision or otherwise, it has been decided to supply each first-class boat with two collision mats, one 6 feet by 4 and one 8 feet by 6.

The fact having been recognized that the eyesight of officers and men serving in torpedo boats is liable to injury when steaming at a high rate of speed, the Admiralty have decided to supply "goggles" or eye-protectors to each boat in the proportion of one for each officer and three for the men.

Several aluminum torpedo tubes have lately been ordered for trial on torpedo boats, a great saving in weight being thus effected. The fittings of a first-class torpedo boat when made of brass weigh about 5 tons; of aluminum, 1.5 tons.

After six sets of twin torpedo tubes had been furnished by the Keyham factory the Admiralty ordered that the remaining torpedo boats of the *Havock* type receive single-barreled tubes, one to be placed forward and one aft.

A third-class torpedo boat belonging to the battle ship *Rodney* was capsized and sunk at Gibraltar on November 14, 1893, while exercising at gun practice. The boat is one of the old type, built in 1880–'82, and is 63 feet long, 8 feet wide, and had a maximum draught of 4 feet 3 inches. She carried a 2-barrel 1-inch Nordenfelt gun mounted on the conning tower, and had on board about one ton of coal and the feed water, the torpedo gear being on board, but no torpedoes. Her crew consisted of 33 men, of whom 3 were on the platform around the conning tower, about 3 feet above the deck. The sea was quite smooth,



HORNET.

United Service Gazette.

and the boat had made a number of runs, turning with a port helm and heeling outwards, when, whilst turning at full speed, she suddenly went over without any apparent reason—so suddenly that one man, who was standing at the bottom of the engine-room ladder, was thrown out into the sea. After turning over the boat up-ended, her stern in air, and remained in this position about ten minutes, then sank in 15 fathoms. She was raised the next day.

In turning previously the boat had heeled 8 to 10 degrees, which appears a good deal, as the edge goes under water at about 12 degrees, and there is no doubt that the accident was caused by the effect of the rudder causing excessive outward heeling. In the later types of torpedo boats care has been taken to so adjust the center of area of the rudder that the reaction of the race deflected by the rudder has a righting effect. A greater beam on less length is also given them, the corresponding type of third-class boats having a length of 60 feet, with an extreme beam of 9 feet 3 inches and a foot more of free-board.

HAVOCK, HARNET, FERRET, LYNX, DARING.

The trial of the *Havock* (p. 150, No. XII), the first of the type to be completed, took place on October 28, 1893, in decidedly heavy weather, the velocity of the wind being recorded as 30 miles per hour. The trial was run in the open sea, the measured-mile runs being made over the Maplin course, and the rest of the 3 hours of the trial off-shore into the North Sea. On the 3-hours' trial the speed was over 26 knots; on the runs over the measured mile the engines averaged 362 revolutions per minute, and developed approximately 3,500 I. H. P. The mean boiler pressure was 165 pounds, although the designed pressure is 180 pounds, while the air pressure was between 2 and 3 inches, the maximum allowed by the admiralty being five.

The results of the runs on the measured mile course are as follows:

Time.		Speed.	Mean Speed.	Second Means.	Final.
min.	*sec.*				
2	10.6	27.565	26.695	26.684	26.783
2	19.4	25.825	26.673	26.883	
2	10.8	27.522	27.094		
2	15	26.666			

The 8-hours' trial for economical speed and also to determine her coal endurance demonstrated that at the speed of 11.2 knots her coal consumption is under one-fourth ton per hour, and at 10 knots it is 3.5 cwts. With her full bunker supply of 60 tons on board she can, therefore, at 10 knots per hour, steam 3,500 miles without recoaling.

The trials as to the steering capabilities of the boat were also

attended with satisfactory results. The rudder, it is claimed, is so proportioned that no appreciable angle of heel is felt when turning, or, if any, the tendency is to cause an inclination of the hull inward, rendering capsizing impossible. Great importance is attached to the proportioning of the rudder to produce this effect, as otherwise under some circumstances dangerous outward inclination might take place, as is generally supposed to have happened in the case of the torpedo boat of the *Rodney*.

In order to test the efficiency of this type of boat for the work they are designed to do, at great speeds, the *Havock* underwent a series of gunnery trials, in fair weather, on April 6. A specially constructed target made to resemble a first-class torpedo boat represented the focus of an evolutionary circle whose radii, 3,500 yards in length, were marked by buoys.

Four series of attacks were made at different speeds, the firing in each case lasting 1 minute. In the first the speed of the attacking boat was 10 knots, and as it approached, bow on, to the target fire was opened from the 12-pounder R. F. G. at a range of 1,500 yards. In the second attack the speed was the same, the firing beginning from the 12-pounder and the 6-pounder R. F. G. at a range of 800 yards, the target bearing about a point forward of the beam. The nearest distance to the target was never less than 700 yards.

In the third series the speed of the *Havock* was 24 knots and the firing from the 12-pounder and the 6-pounder guns began at 1,500 yards, steaming bow on, the distance run being about 800 yards. In the fourth series, at the highest possible speed, the 12-pounder was used at 1,100 yards and for a distance of about 800 yards.

The target was carefully examined after each order of firing and the number of hits recorded. The firing was principally directed at the conning tower and the examination showed that the rounds from the 6-pounder using live shell, which scattered on impact, produced more destruction than the solid projectiles of the 12-pounder.

The results of the firing were highly satisfactory, and it was generally agreed that no torpedo boat could have withstood the attack.

In his report, the officer who superintended the experiments states that the value of the 12-pounder mounting above the conning tower is confirmed, as the gun hit and pierced the smoke-pipe of the dummy torpedo boat in 8 rounds at 1,200 yards, the *Havock* having then a good speed. It pierced the boiler, conning tower, and the compartment between at 800 yards in 8 rounds on the second run; it pierced the smoke-pipe twice in 7 rounds on the third run; and the turtle deck and conning tower with 8 rounds on the fourth run. An average of 6 carefully aimed shots per minute was maintained and the supply of ammunition could keep pace with this rate, but could not be made faster.

In general appearance the *Havock* differs but little, except as to size, from the the ordinary first-class torpedo boats built by the same firm.

She has a long turtle-backed deck forward, rising well above the water line; this gives a roomy forecastle, in which the larger part of the crew is berthed. From the after end of the forecastle rises the conning tower. A single pole mast serves for signal purposes.

Armament.—One 12-pounder R. F. G., mounted on the conning tower and having an all-around range. Two 6-pounder, R. F. G., in broadside, and 1 aft. Three torpedo tubes for 18-inch Whitehead torpedoes, one in the bow, fixed, and twin tubes aft, on a training carriage. The later boats have 2 single training tubes in place of the twin tubes.

Motive power.—Two triple-expansion engines with cylinders 18, 26, and 39.5 inches in diameter, by 18-inch stroke. The *Havock* has 2 boilers of the locomotive type, with copper fire boxes and copper tubes, designed for a working pressure of 180 pounds. The total grate surface is about 100 square feet, and the total heating surface about 5,000 square feet. The propellers are three-bladed.

Dimensions.—Length on load-water line, 180 feet; extreme breadth of beam, 18 feet 6 inches; displacement, 220 tons, at which the draught of water is 6 feet.

The complement for this type of torpedo boat is 42 officers and men.

The official trial of the *Hornet* (p. 150, No. XII) took place on March 19, 1894, and is noteworthy as having developed the highest speed yet recorded for the period of three hours' successive steaming. Previous to the official trial a private trial was run in January, the boat having at that time but 4 of her 8 boilers on board; a speed of 23.3 knots was realized, the boilers working at a very moderate air pressure but supplying with ease all the steam required.

On February 23, another trial was made under the full complement of boilers, resulting in the remarkable speed of 28 knots, the highest steaming speed as yet made by any vessel at sea; the engines on this trial made an average of nearly 400 revolutions per minute, the boiler pressure of 172 pounds being maintained with an air pressure of a little over one inch.

On March 19 the *Hornet* made her official trial under forced draft, during which 6 runs were made on the Maplin mile course with the following results:

Time of day.	Revolutions.		Time.	Speed.	Means.	Second means.	
	Starboard.	Port.					
			M. S.				
10:28	395.9	395.4	2 17.6	26.163	27.322	27.370	27.313
10:34	384.4	386.8	2 6.4	28.481	27.418	27.395	
10:43	384.7	392.2	2 16.6	26.355	27.373	27.306	
10:52	391.3	392.7	2 6.8	28.391	27.239	27.183	
11:02	380.0	381.7	2 18	26.087	27.128		
11:10	394.3	394.3	2 7.8	28.169			

The average boiler pressure was 170 pounds; air pressure, 1.5 inches, and vacuum, 26 inches.

On the completion of the runs over the measured mile the vessel, for the remainder of the trial time, was run straight out into the North Sea and on the expiration of the three hours was found to have realized a mean speed of 27.628 knots, the mean revolutions being 388.3 per minute, I. H. P., 4,000, mean boiler pressure, 169 pounds, and air pressure, 1.5 inches.

The *Hornet* is a sister vessel of the *Havock* and was built at the same works; the exterior appearance of the vessels is identical except that the *Havock* has 2 smoke-pipes while the *Hornet* has 4, one for each pair of her water-tube boilers.

The main difference between the vessels lies in the boilers, those of the *Hornet* being of the water-tube type designed by Messrs. Yarrow, there being 8 boilers in 2 groups of 4, having a total grate surface of 164.8 square feet and a total heating surface of 8,216 square feet. A marked feature of the trial was the ease with which the steam was kept under control and the facility with which the feed was regulated, there being no signs of priming or water in the engine cylinders at any time. The 8 boilers weigh 43 tons, as against 54 tons, the weight of the *Havock's* locomotive boilers. The engines of both boats are the same.

The *Ferret* (p. 150, No. XII) is reported to have made over 28 knots on her trials over the measured mile.

The *Lynx* (p. 150, No. XII) is reported to have made 26.5 knots.

The trials of the *Daring* (p. 150, No. XII) over the measured-mile course off Maplin Sands resulted in a speed of 28.656 knots as the mean of three runs, and a maximum speed of 29.268 knots for one run, against the tide. The mean I. H. P. developed was 4,573, the maximum being 4,842, and the average of the revolutions per minute during the 3 runs was 387.

The following particulars of the trial are from the London *Times:*

	Duration of run.		Speed per hour.
	Min.	*Sec.*	*Knots.*
Against the tide	2	7.6	28.214 (28.392)
With the tide	2	6	28.571 (28.656)
Against the tide	2	3	29.268 (28.919)

Previous to making the above runs for maximum speed some progressive trials, consisting of 4 series of 3 runs each, were made over the same course, resulting as follows:

Series.	Mean revolutions per minute.	Mean speed in knots, per hour.
1	91	7.864
2	175	14.200
3	237	18.342
4	321	23.210

The turning trials showed the boat's tactical diameter to be about 500 feet; at 210 revolutions the time occupied in making a complete circle was one minute, fifty-six seconds. In turning at greater speed the heel was very slight, and the vibration, when going at maximum speed, was not excessive. A serious drawback is the column of flame which, at high speed, rose to a height of from 12 to 15 feet above the smoke pipes, and which would have rendered the boat visible at a great distance at night, besides affording an excellent target.

The boilers of the *Daring* are of the Thornycroft improved water-tube type. She has 2 rudders, also of Messrs. Thornycroft's patent.

Nos. 90, 92, 93, 97.

Of the 10 first-class torpedo boats provided for in the estimates for 1893–'94, four have been tried, with the following results:

No. 90.—Attained a mean speed over the measured mile course of 24 knots. No. 90 is the only torpedo boat in the English navy fitted with a quadruple-expansion engine.

No. 92.—The mean of six runs over the measured mile with and against the tide gave a speed of 24.52 knots. A strong wind was blowing at the time of the trial, causing a rough sea. On the three hours' continuous steaming trial a mean of 24.12 knots was made.

No. 93.—The official trials of torpedo boat *No. 93*, which is the only one of the new type fitted with twin screws, took place off Sheerness in December, 1893. On the first trial, with a steam pressure of 225 pounds per square inch, and engines making 472 revolutions per minute, a speed of 23.8 knots was attained. On the continuous three hours' trial the mean revolutions were 467 and the speed 23.5 knots.

This boat has a length of 140 feet and an extreme breadth of 15 feet 6 inches; the displacement is about 110 tons and load draught 5 feet 4 inches; she has triple-expansion engines capable of developing 2,000 I. H. P., the steam for which is supplied by two Thornycroft water-tube boilers. Her armament consists of three 3-pounder R. F. G. and she has three 18-inch torpedo tubes.

The remaining boats vary in length from 140 to 145 feet and in breadth from 14 feet 3 inches to 14 feet 9 inches. Three were built by

Messrs. Thornycroft, 3 by Messrs. Laird, 3 by Messrs. Yarrow & Co., and 1 by Mr. White, of East Cowes. They are fitted with the various classes of boilers built by those firms, some water-tube and some of the dry bottom locomotive type. The estimated horse power is 1,600; speed 24 knots. Their load draught is about 6 feet and coal capacity, 30 tons; complement, 21.

No. 97.—The trials of *No. 97* were not altogether satisfactory, as the contract speed of 23 knots was not made, and further trials will have to take place. During the forced-draft trials of three hours a mean speed of 22.7 knots was made, while the mean of the runs on the measured mile course was 22.8 knots.

A 56-foot, third-class boat, built by Mr. White, of East Cowes, and fitted with his coil water-tube boiler, has made a successful trial. With steam at a pressure of 160 pounds and an air pressure of 1.8-inches, she made an average speed of 14.57 knots over a two hours' run.

FRANCE.

In France the fiscal year begins on the 1st of January, and the appropriations for the coming year are made previous to this date—generally in the summer. This enables the navy department to prepare for the coming expenditures—giving time for the preparation and discussion of the plans and designs for the new construction.

The total amount appropriated for the fiscal year beginning January 1, 1894, according to the naval budget which was passed in July, 1893, was 266,861,528 francs ($51,504,275). This was an increase of 11,403,995 francs ($2,200,971) over the appropriations for the previous year. The amount set apart to be expended in 1894 on vessels building and authorized was 76,248,918.50 francs ($14,716,141).

The estimates submitted by the minister of marine for the year 1895 amount to 277,516,311 francs ($53,560,648), being an increase of 10,654,-783 francs ($2,056,373) over the appropriations for 1894.

It is to be noted that the French Government is still carrying out the construction programme adopted in 1891 (p. 27, No. XI). Both the Government and the private shipbuilding establishments have been actively employed, and the new estimates provide for a continuance of this activity; probably at no time have there been so many vessels building and completing as at the present. The vessels launched in 1893 have a combined tonnage of 52,188.

VESSELS PROPOSED OR LAID DOWN.

BATTLE SHIP A⁷.

The estimates for 1895 provide for 1 battle ship A^7, to be built by the Government; it is estimated to cost 24,000,000 francs ($4,632,000), the same as the *Charlemagne.*

RAYMOND (S^2).

A dispatch vessel named *Raymond*, and estimated to cost 2,000,000 francs ($386,000), is to be built by the Government.

HENRI IV, CHARLEMAGNE, SAINT LOUIS.

The three battle ships mentioned as A^3, A^4, A^5 (p. 155, No. XII.), have been named, respectively, as above. The *Charlemagne* and *Saint Louis* will be built by the Government; the former at Brest and the latter at Lorient. The *Henri IV* will be built by contract, probably at St. Nazaire, but according to the estimates will not be laid down prior to 1895. These ships will be more wall-sided than the *Jauréguiberry* type (p. 31, No. X), their lengths will exceed those of any other French battle-ships, giving lines from which a higher speed will be obtained, and the high freeboard forward assures good seagoing qualities. In comparison with the French battle ships already built these new vessels will have an armament reduced in both caliber and number of guns, and consequently in weight. It is claimed that this diminution of offensive power is, perhaps, more in appearance than in reality, owing to the improvements in the protection and disposition of the guns and in the superiority of the new models. The protection, on the other hand, has been notably increased, perhaps the greatest that has as yet been devised in France, for the secondary battery and torpedo tubes. There has been also an increase in the subdivision of the compartments. These vessels, for battle ships, are expected to possess to a marked degree the qualities of speed and stability.

Armament.—Four 30-centimeter (11.8-inch) B. L. guns in pairs in two turrets (Farcot type) at the extremities; ten 14-centimeter (5.46-inch) R. F. G., eight being in a central steel casemate on the main deck with splinter screens between guns, and two in sponsons on the upper deck; six 10-centimeter (3.94-inch) R. F. G., on the spar deck; sixteen 47-millimeter R. F. G.; eighteen 37-millimeter R. C., and ten torpedo tubes, four being under water. The emplacement of the battery provides for firing—ahead and astern, two 11.8-inch, six 5.46-inch, and four 3.94-inch guns; abeam, four 11.8-inch, five 5.46-inch, and three 3.94-inch guns. The two bow turret guns (11.8-inch) have a height above water of 27 feet 10 inches, while the two aft have 21 feet 4 inches. Arrangements are made for working the guns and turrets both by hand and by electricity. It is also observed that part of the secondary battery is placed below the main deck.

Protection.—Complete water-line belt of hardened steel, 15.7 inches maximum thickness; a steel protective deck, 3.5 inches thick, and a steel splinter deck 1.5 inches thick. The compartments formed between the protective and splinter decks will be partly filled with coal.

Motive power.—Three sets of triple-expansion engines, 4 cylinders each, driving 3 screws and estimated to develop 14,000 I. H. P. under

forced draft and to give a speed of 18 knots. The maximum coal capacity will be about 1,100 tons, and the steaming radius, at 10 knots, 4,000 miles.

Dimensions.—Length, 385 feet 5 inches; beam, 66 feet 7 inches; mean draught, 25 feet 10 inches; displacement, 11,260 tons.

In the accompanying cut, taken from *Le Yacht*, AA are the ammunition passages for the 14-centimeter, 10-centimeter, 47-millimeter, and 37-millimeter guns; BB, the ammunition passages for the 30-centimeter guns; CC, coal bunkers; DD, boilers; F, chart room; G, conning tower; H, searchlights; KK, condensers; MM, engines; PP, stations for torpedo directors; TT, axis of the 30-centimeter gun turrets; VV, ammunition scuttles; *mm*, 14-centimeter R. F. G.; *nn*, 10-centimeter R. F. G.; *pp*, 47-millimeter R. F. G.; *qq*, 37-millimeter R. C.; *uu*, torpedo launching tubes.

CASSARD (G^4) LAVOISIER (H^3).

Of the cruisers provided for in the budget for 1894 (p. 155, No. XII), only two have been laid down, viz, G^4, which has been named *Cassard*, and H^3, which has been named *Lavoisier*. Both will be built by the Government, the former at Cherbourg and the latter at Rochefort. It is estimated that 8 per cent of the construction of these vessels will be accomplished in 1894.

CASABIANCA.

(Page 29, No. XI; 154, No. XII.)

The keel of this torpedo vessel was laid in the latter part of 1893 at Bordeaux by the Société de la Gironde.

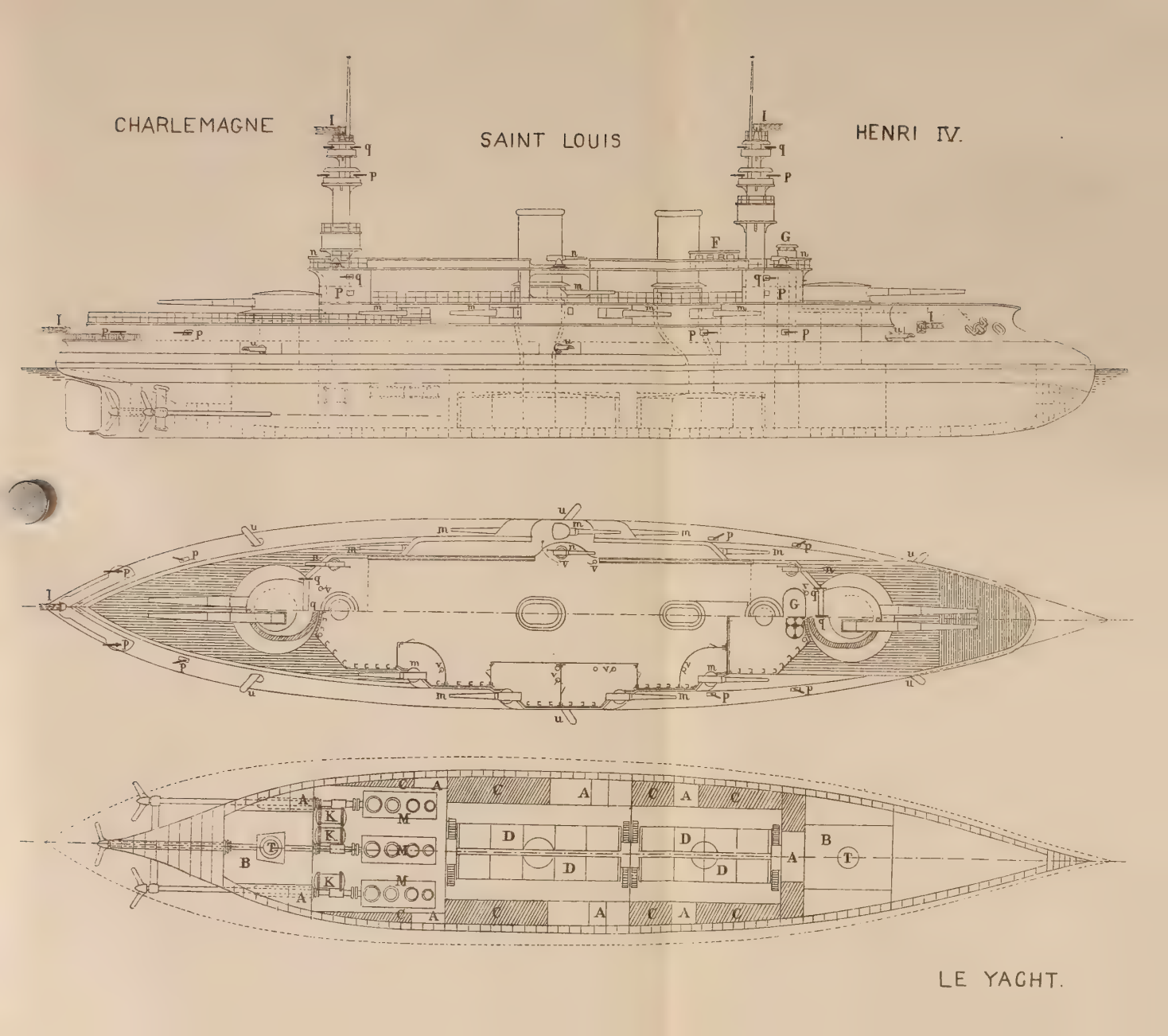
D'ENTRECASTEAUX (N).

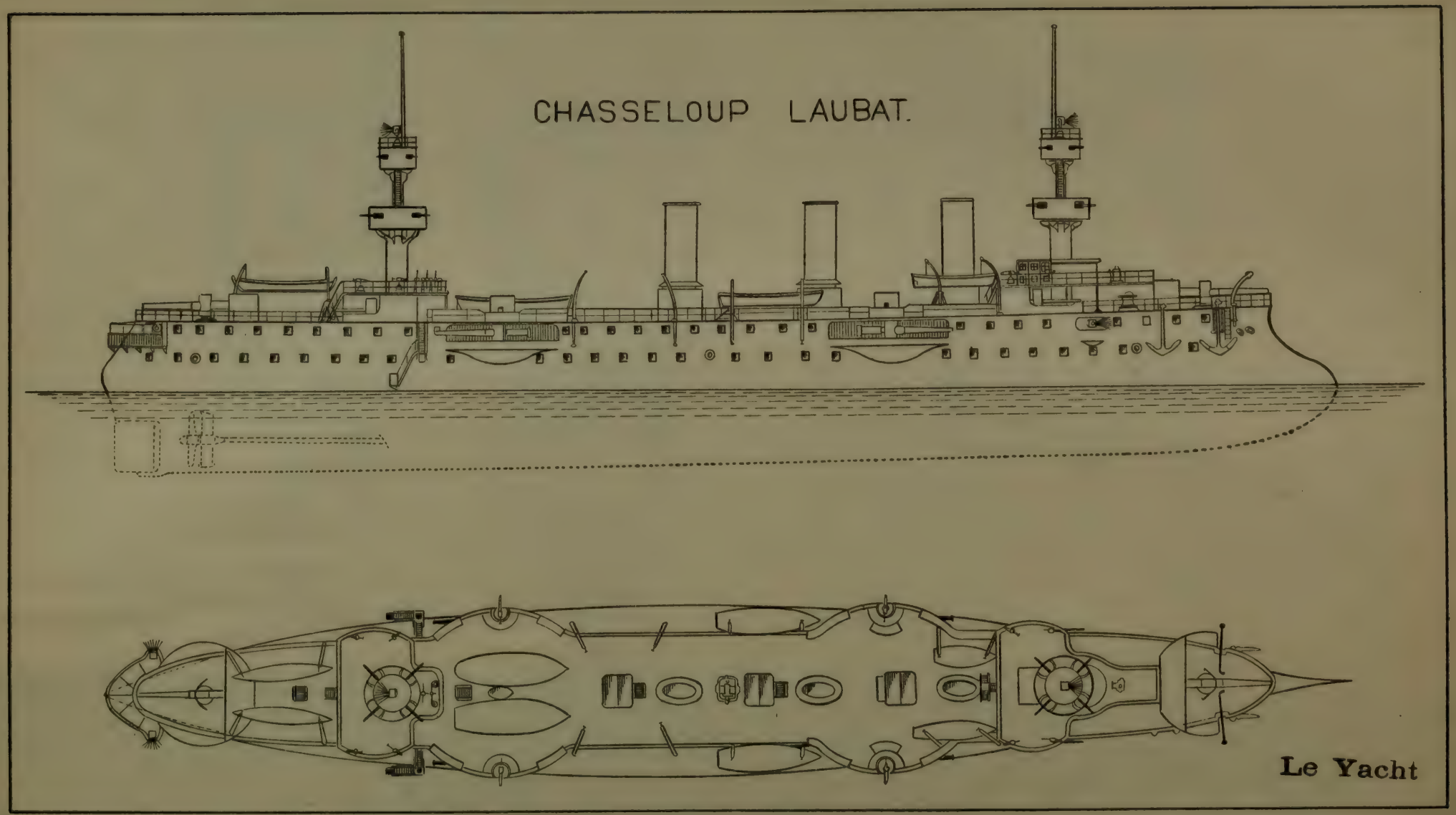
(Page 30, No. XI; 153, No. XII.)

The contract for the construction of the *D'Entrecasteaux* has been given to the Forges et Chantier de la Mediterranée, who have only recently (1894) commenced the construction of this vessel at La Seyne, on a design by their naval constructor, M. Lagane. Being intended for foreign service, this vessel will be sheathed and coppered. Electric machinery will be used for working the turrets, the ammunition hoists, steering gear, capstans, ventilators, etc., and all the auxiliary machinery will be placed below the protective deck.

Armament.—Two 24-centimeter (9.4-inch) B. L. in two turrets (Farcot type) at the extremities; twelve 14-centimeter (5.46-inch) R. F. G., four being on the spar deck in the waist with shields 2.75 inches thick, and eight on the main deck *en échelon;* twelve 47-millimeter R. F. G.; four 37-millimeter R. C., and seven torpedo tubes. Separate magazine and ammunition hoists are provided for each gun of the main battery.

Protection.—Steel protective deck, 4 inches thick, and a steel splinter deck, the space between these decks being divided into a large number of compartments, some of which are to contain the reserve liquid fuel.


CHARLEMAGNE
SAINT LOUIS
HENRI IV.
LE YACHT.


CHASSELOUP LAUBAT.
Le Yacht

Motive power.—Two sets of triple-expansion engines, driving twin screws, to develop 14,000 I. H. P. and give an estimated speed of 19 knots under forced draft. There is a novel arrangement in the position of the boilers, four being forward of the engines, while the fifth is abaft the engines and between the two shafts.

Dimensions.—Length, 384 feet 6 inches; beam, 58 feet 6 inches; mean draught, 24 feet 7 inches; displacement, 8,087 tons.

JEANNE D'ARC (O).

The armored cruiser *O* (p. 153, No. XII), provided for in the budget for 1893, and the laying down of which was temporarily postponed, has been named *Jeanne d'Arc*. The vessel will be built by contract and is expected to be, in all essential features, similar to the *D'Entrecasteaux*.

CATINAT (P).

The protected cruiser *P* (p. 154, No. XII), of the type *Chasseloup-Laubat* (p. 32, No. X), has been named *Catinat*. The contract was signed in February, 1894, and requires the vessel to be delivered in February 1897. She is being built by the Société de la Mediterranée at their Graville yard, near Havre. Being designed for service in foreign waters, the vessel will be sheathed.

Armament.—Four 16-centimeter (6.3-inch) R. F. G. in sponsons on main deck; ten 10-centimeter (3.94-inch) R. F. G., four being on main deck under the topgallant forecastle, two on the topgallant forecastle, two upon and two under the poop—all the guns are mounted *en échelon;* fourteen 47-millimeter R. F. G.; four 37-millimeter R. C., and six torpedo tubes.

Protection.—Protective deck, 1.5 inches maximum thickness, below which is to be a splinter deck.

Motive power.—Two sets triple-expansion engines, driving twin screws to develop 9,000 I. H. P. and give a speed of 19 knots.

Dimensions.—Length, 318 feet 6 inches; beam, 41 feet 4 inches; mean draught, 19 feet 8 inches; displacement, 3,990 tons.

The following vessels provided for in the budget for 1894 (p. 155, No. XII) will not, according to the estimates, be taken into hand prior to 1895:

Henri IV, battle ship; E^4, E^5, E^6, G^3, protected cruisers; U^1, dispatch vessel.

VESSELS LAUNCHED.

CHARLES MARTEL.

(Page 31, No. X.)

The *Charles Martel*, the largest vessel built thus far by the French Government, was launched at Lorient in August, 1893, having been just two years under construction. It is estimated that 84 per cent of the construction of this vessel will be completed by the end of the present year.

JAUREGUIBERRY.

(Page 31, No. X.)

The *Jauréguiberry* was launched at La Seyne in October, 1893, being 23 months after the keel was laid. It is estimated that she will be ready for the contract steam trials in July, 1895. The vessel has been constructed upon the plans and under the direction of M. Lagagne, the eminent constructor of the progressive shipbuilding establishment Société des Forges et Chantiers de la Mediterranée. The interesting features peculiar to this French battle ship and to the designer are:

(1) The distribution of the 5.46-inch R. F. G. in pairs in turrets.

(2) The subdivision between the protective deck and that next below it.

(3) The electrically controlled turrets, which have an unvarying center of gravity regardless of the position of the gun, and the electrical control of auxiliary machinery, such as ammunition hoists, ash hoists, and control of steering gear. There is no hydraulic machinery on board.

The principal characteristics of this vessel, although given on p. 31, No. X, are here repeated, in order to accompany the illustrations in this number.

Armament.—Two 30-centimeter (11.8-inch) B. L. in balanced turrets, on axis of ship, one forward and one aft; two 27-centimeter (10.6-inch) B. L. in sponsoned turrets at the sides and on a lower level; eight 14-centimeter (5.46-inch) R. F. G., in pairs in four turrets at each corner of the central battery; four 9-pounder, and twelve 3 pounder R. F. G.; eighteen 37-millimeter R. C., and six torpedo tubes, two of which are submerged. The disposition of the main battery permits the firing ahead and astern of one 11.8-inch, two 10.6-inch, and four 5.46-inch guns, abeam of two 11.8-inch, one 10.6-inch, and four 5.46-inch guns, the latter representing a weight of fire of 6,600 pounds in every 5 minutes.

Protection.—Complete water-line belt, 10.8 to 17.7 inches thick; protective deck, 2.7 inches; turrets for the heavy guns, 14.6 inches; turrets for the light guns and the armored cofferdams, 3.9 inches.

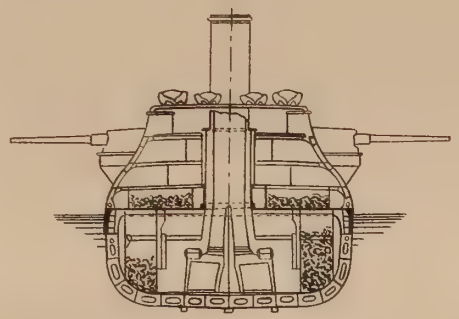
Motive power.—Two triple-expansion engines driving twin screws; 24 tubulous boilers of the d'Allest type, to give an estimated horse power of 12,500 natural draft and a speed of 17 knots. With forced draft the estimated horse power is 14,200.

Dimensions.—Length, 356 feet; beam, 72 feet 6 inches; mean draught, 27 feet; displacement, 11,824 tons.

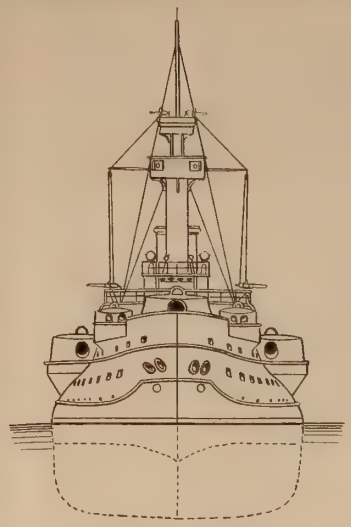
BUGEAUD.

(Page 27, No. IX; 32, No. X.)

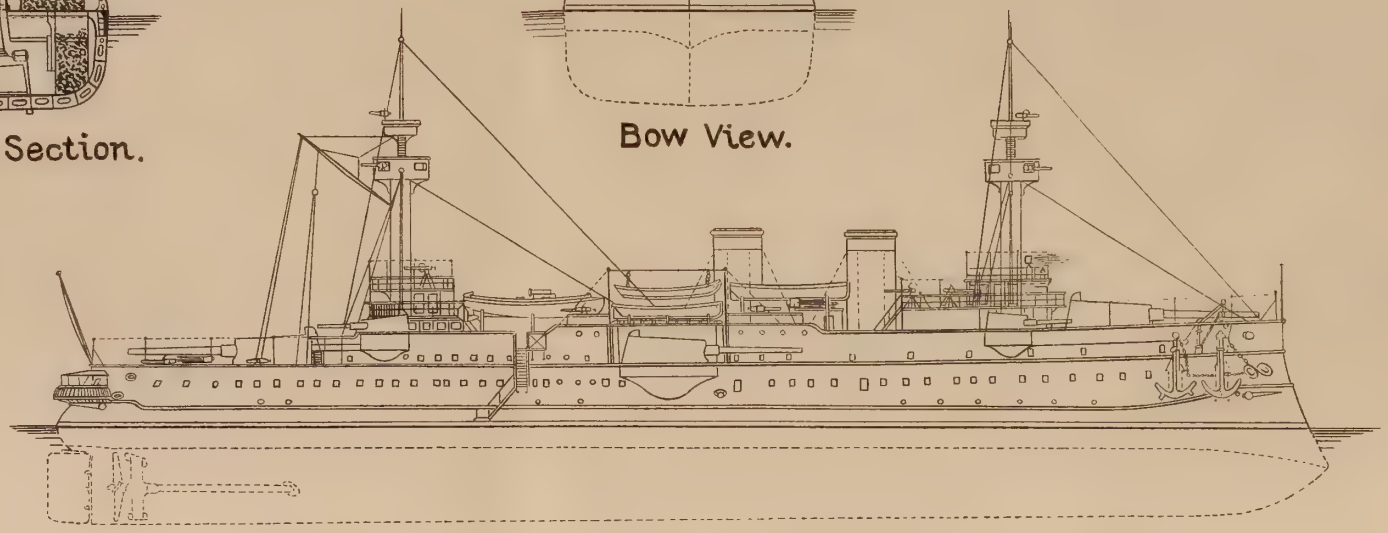
This protected cruiser was launched at Cherbourg in September, 1893. It is estimated that 79 per cent of her construction will be executed by the end of the present year. In the distribution of the main

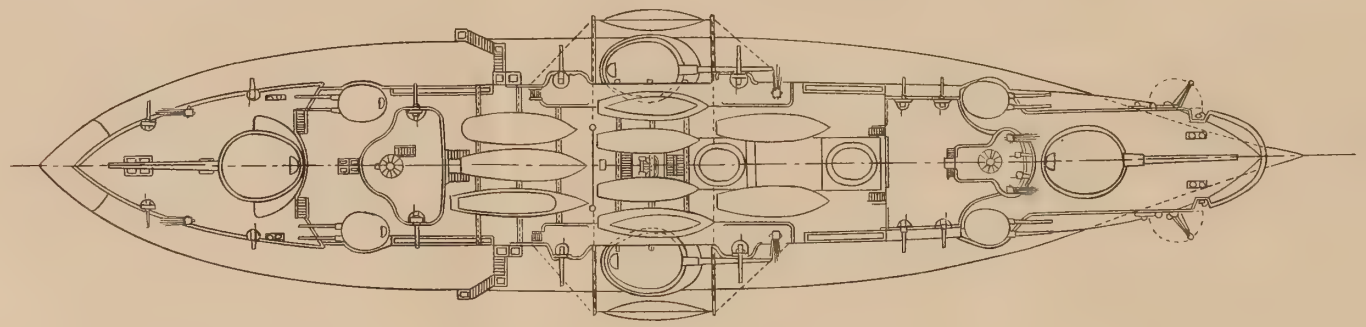


Midship Section.



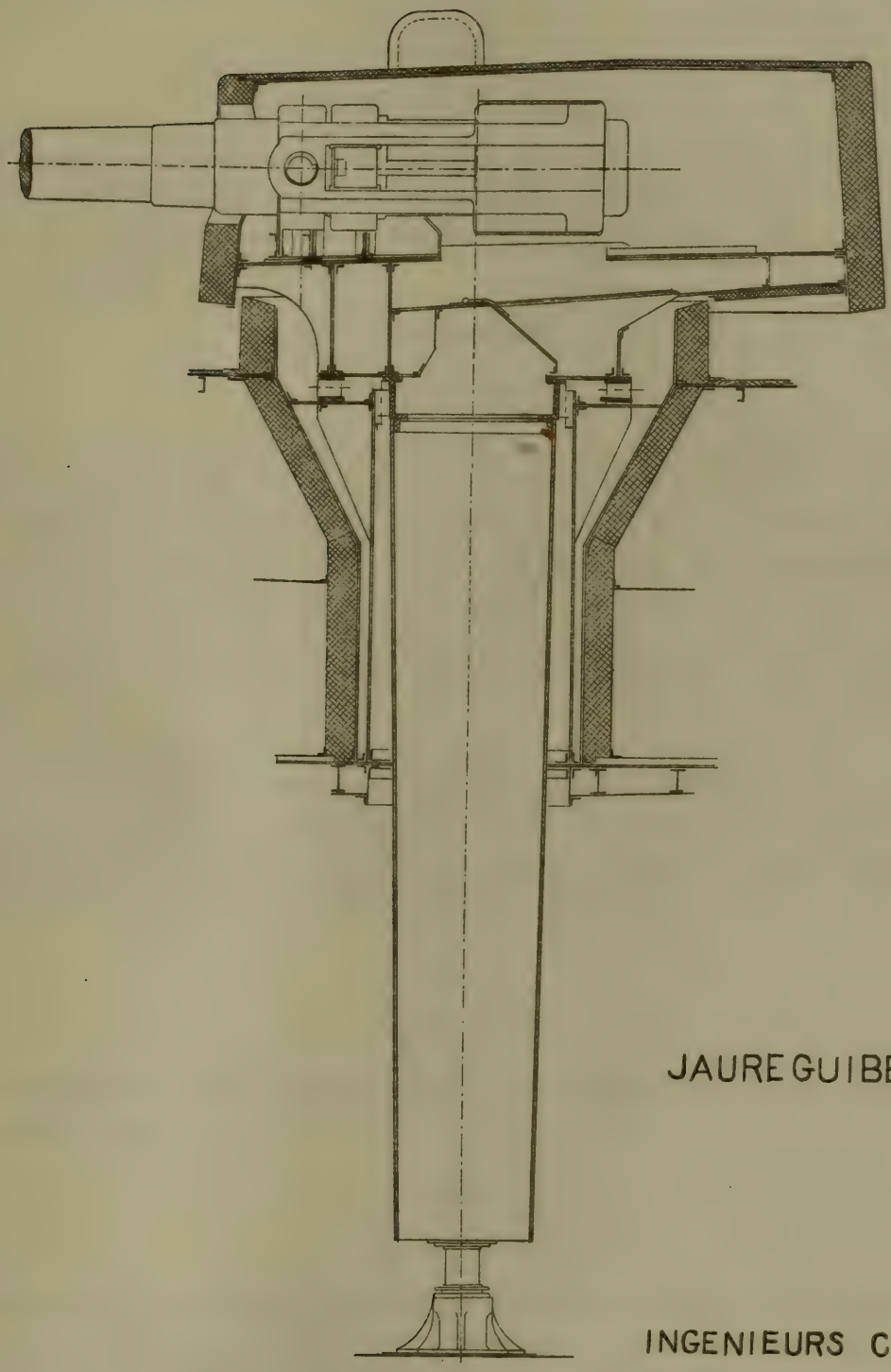
Bow View.





THE JAUREGUIBERRY

Le Yacht



JAUREGUIBERRY.

INGENIEURS CIVILS.

battery (p. 32, No. X) four of the six 16-centimeter (6.48-inch) R. F. G. are in sponsons in the waist, one on the bow, and one aft, while the four 10-centimeter (3.94-inch) R. F. G. are placed two forward and two abaft the four central 6.48-inch guns. This permits firing ahead and astern of three 6.48-inch and two 3.94-inch guns; abeam of four 6.48-inch and two 3.94-inch guns.

SUCHET.

(Page 257, No. VI; 38, No. X.)

This protected cruiser was launched at Toulon in August, 1893, with masts complete and boilers in place, being the first time a vessel had been thus launched at one of the Government yards. The vessel has been completed this year.

D'IBERVILLE.

(Page 29, No. XI.)

This torpedo vessel was launched at St. Nazaire, Société de la Loire, in September, 1893, and has been completed this year.

Armament.—One 10-centimeter (3.94-inch) R. F. G., on forecastle; three 65-millimeter (9-pounder) R. F. G., one on poop and one each broadside; four 37-millimeter R. F. G., and six torpedo tubes, distributed as follows: One in the stem, one in the stern, two (twin tubes) forward on the starboard side, and two (twin tubes) aft on the port side, all above water.

Protection.—Steel deck, 0.6 inch thick.

Motive power.—Quadruple-expansion engines, driving twin screws, and to give 21.5 knots with 5,000 I. H. P.

Dimensions.—Length, 262 feet 5 inches; beam, 28 feet 5 inches; draught, 10 feet 9 inches; displacement, 925 tons.

CASSINI.

(Page 29, No. XI.)

This torpedo vessel, a sister ship to the *d'Iberville*, was launched at Havre on June 5, 1894.

LINOIS.

(Page 28, No. XI.)

This protected cruiser, type modified *Forbin* (p. 37, No. X), begun in January, 1893, was launched at La Seyne in January, 1894.

Armament.—Four 14-centimeter (5.46-inch) R. F. G., mounted in large sponsons on the main deck; two 10-centimeter (3.94-inch) R. F. G., one on the forecastle and one on the poop; four 47-millimeter R. F. G., six 37-millimeter R. C., and four torpedo tubes.

Protection.—Complete steel deck, 1.5 inches thick; boilers and engines have coal on sides and overhead and double bottom underneath.

Motive power.—Two sets triple-expansion engines, driving twin screws, estimated to develop 6,600 I. H. P. and to give a speed of 20 knots.

Dimensions.—Length, 334 feet 7 inches; beam, 34 feet 5 inches; mean draught, 14 feet 5 inches; displacement, 2,270 tons.

CHANZY.

(Page 341, No. VIII; 27, No. IX.)

This armored cruiser was launched at Bordeaux, Société de la Gironde, in January, 1894, with armor, turrets, masts, davits, machinery, and boilers in place. Within a month after launching the vessel steamed to Rochefort with her own power. This method of completing before launching is resorted to in France where water front is scarce.

STEAM TRIALS.

DUPUY-DE-LÔME.

(Page 312, No. VII; 35, No. XI.)

In May, 1893, this vessel again began her steam trials. On a preliminary trial, May 2, the vessel averaged 15 knots for 6 hours. A shock having been observed in one of the cylinders necessitated a cessation of further trials till July, when a hot eccentric interrupted a preliminary forced-draft trial, the vessel making at the time a speed of 19.7 knots. In October, 1893, while undergoing the 24 hours' natural-draft trial 2 of the 3 Fox corrugated furnace crowns collapsed. The ship was making 19 knots when the mishap occurred. This has disabled the ship for another term while alterations are being made. The boilers have been taken out for modification.

COËTLOGON.

(Page 29, No. IX; 38, No. X; 35, No. XI.)

In March, 1894, this vessel met with further delays in the steam trials; both engines had to be stopped, one on account of friction. In April, on preliminary trial, the vessel worked at sea for 5 hours at a speed of 18 knots, but it is reported that the vibrations were so excessive that the compasses were nearly useless.

In June, 1894, the vessel completed her 6 hours' trial with satisfactory results. The contract required a speed of 19.5 knots, and on this trial, under forced draft, the speed obtained was 20.4 knots.

D'IBERVILLE.

In May, 1894, on a preliminary trial this vessel gave a speed of 21 knots with modified forced draft, and it is estimated that a speed of 22

knots will be obtained. It is thought the *d'Iberville* will be the best scout vessel in the French fleet.

ISLY.

(Page 34, No. X.)

In May, 1893, this vessel completed the contract steam trials, making 17.9 knots for 6 hours under natural draft and 18.5 knots for 2 hours under forced draft, developing 8,100 I. H. P., and exceeding the contract by 100 H. P. The forced-draft trial took place in unfavorable weather which, it is estimated, reduced the speed by half a knot.

MAGENTA.

In August, 1893, the *Magenta* on trial made 16.2 knots for 2 hours under forced draft.

The value of the *Magenta* as a war vessel has been recently severely criticised in the French press. The vessel was accordingly subjected to special trials under the supervision of a subcommittee of the parliamentary inquiry commission appointed in 1894.

Like all war vessels, the *Magenta* has her faults, and it is quite evident from the various reports that she is a very tender ship, which, on the other hand, gives a steady gun platform. The defective feature in the *Magenta* is found in the unprotected condition of the main deck, where are mounted twelve 5.46-inch R. F. G. and 2 torpedo tubes.

The following is a translation of the concluding portion of Admiral Vallon's report upon the vessel, he being the expert member of the inquiry commission:

From the whole of these observations we conclude that the *Magenta* is neither better nor worse than the other modern battle ships of our fleet, although her stability, fully laden, seems a little less assured. If she should heel there would be risk. Even the very perfection of her arrangements is a danger to constructors influenced by example, by superior orders, or by what may be called progress without experience.

SUCHET.

(Page 257, No. VI; 38, No. X.)

This vessel underwent steam trials in the spring of 1894 as follows:

March 20, a forced-draft trial of 2 hours' duration, giving a mean speed of 20.42 knots with 8,842 I. H. P. The contract required a speed of 20 knots under forced draft.

April 9, a modified forced-draft trial of 6 hours, giving a mean speed of 18.24 knots with 6,210 I. H. P.

From 9 a. m. April 16 to 9 a. m. April 17, a natural-draft trial of 24 hours, the mean speed being 16.73 knots with 4,119 I. H. P. In this run the average revolutions of the engines were 105, the consumption of coal per horse power per hour 1.78 pounds.

April 23, a speed of 15 knots was obtained with 2,500 I. H. P., and a speed of 10.8 knots with 1,000 I. H. P.

FULMINANT.

This coast-defense vessel, launched in 1877, having received new boilers, underwent, in the spring of 1894, a 6 hours' steam trial, attaining a speed of 14 knots.

TORPEDO BOATS.

The following torpedo boats provided for in the budget for 1894 (p. 155, No. XII) will not be taken into hand prior to 1895:

N^{12}, torpedo boat, first class; P^{22}, P^{3}, P^{24}, Q^{1}, Q^{2}, Q^{3}, Q^{4}, torpedo boats, second class; R^{4}, R^{5}, R^{6}, R^{7}, R^{8}, R^{9}, torpedo boats, third class.

CHEVALIER, MOUSQUETAIRE, CORSAIRE.

(Page 39, No. X; 37, No. XI.)

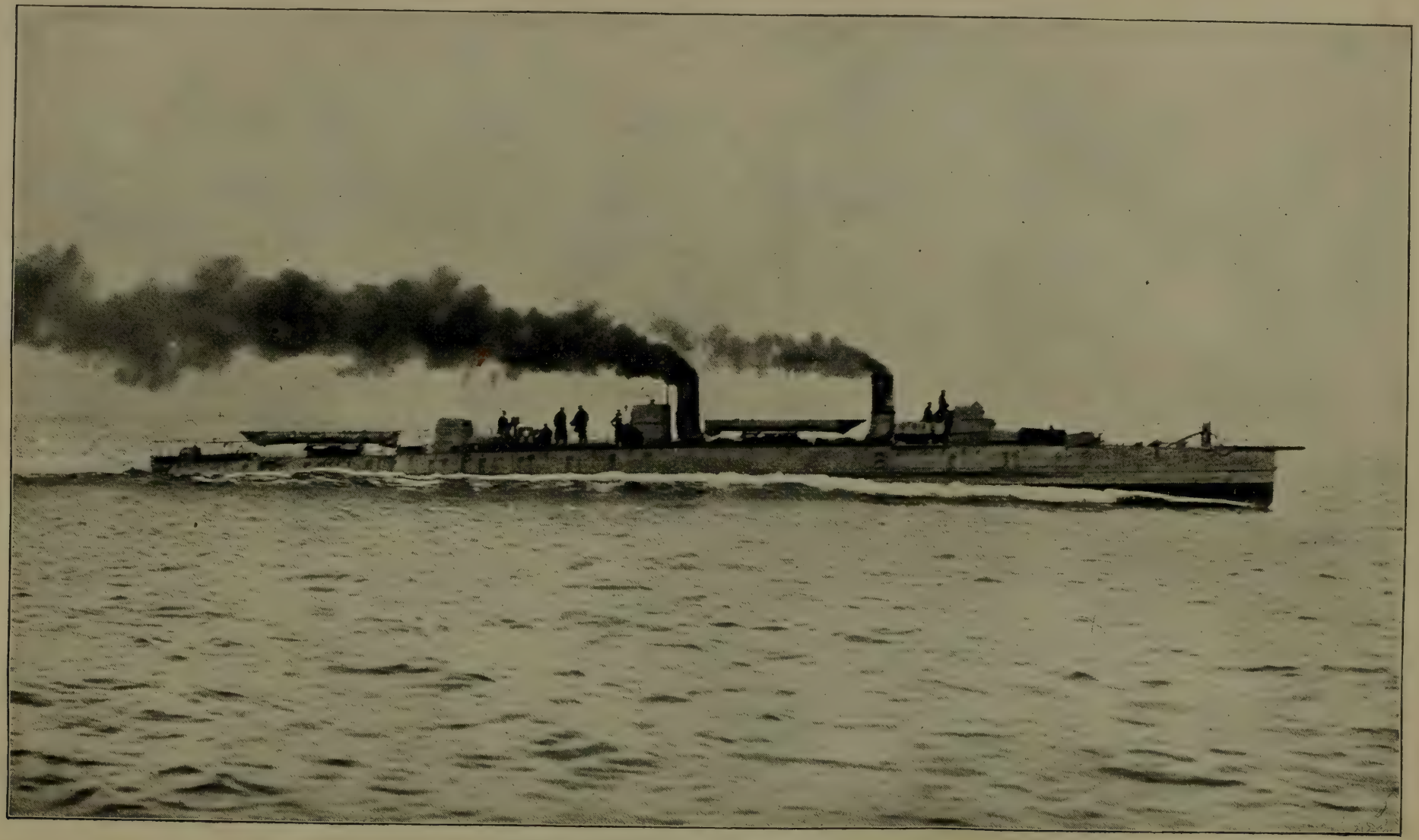
In the last months of 1893 the above-named first-class torpedo boats underwent the contract steam trials. These typical French boats serve to illustrate the progress in torpedo boat building by three separate establishments. As was noted on page 37, No. XI, the *Chevalier* was constructed by M. Normand, at Havre, the *Mousquetaire* by the Forges et Chantiers de la Mediterranée, at their Graville yard, and the *Corsaire* by the Ateliers et Chantiers de la Loire, at St. Denis.

The *Chevalier*, of 125 tons displacement, is said to have good quarters and ample deck room. The *Mousquetaire*, 135 tons displacement, stands well out of water, presenting a staunch, seaworthy appearance; the quarters are said to be extremely comfortable and well fitted, and the deck is not encumbered. The *Corsaire*, of 165 tons displacement, has low upper works, the ends sloping away, and the deck space is said to be contracted and encumbered.

The *Chevalier*, on trial, made an average speed of 27.22 knots for the period required—that is, about two hours; the *Mousquetaire* made an average speed of 24.77 knots for the same period, and the *Corsaire* 24.28 knots. Each boat had on board sufficient coal to steam a distance of 1,000 knots, at a speed of 10 knots, in addition to their armament and crew, or an equivalent weight. In addition to the highest speed the *Chevalier* further presents an interesting feature in having fitted on board a contrivance, invented by M. Normand, to prevent the unpleasant vibrations at high speed and which is intended to preserve the hull and ease the machinery.

SARAZIN, TOURBILLON.

The trials of the first-class torpedo boats *Sarazin* and *Tourbillon* condemned the type of boilers (Bobillot) in those boats. On trial in January, 1894, one of the boilers of the *Sarazin* explored, killing 2 engineer officers and 5 firemen, the result being that all the boats having these boilers have been returned to the builders (Société de la Gironde, Bordeaux) for the substitution of another kind of boiler. The



CHEVALIER, OCTOBER 13, 1893. Speed 27.22 knots.

MOUSQUETAIRE, AUGUST 10, 1893. Speed 24.77 knots.

CORSAIRE, JULY 29, 1893. Speed 24.28 knots.

boats affected, in addition to the *Sarazin* and *Tourbillon*, of 104 tons displacement, are the second-class boats *Nos. 155*, *156*, *157*, *158*, *159*, and *160*, of 80 tons displacement.

In the following table are noted the contract or estimated speeds of certain torpedo boats building, together with the results of the speed trials of other boats which have been completed and undergone trials since the publication of No. XII.

Name.	Displacement.	I. H. P.	Speed.		Builders.	Remarks.
			Contract.	Trial.		
	Tons.		*Knots.*	*Knots.*		
Archer	120	1,250	20.50	21	Normand	Machinery of the wrecked Avant-Garde.
Argonaute	120	1,500	23.50	25.1	At. de la Loire	
Aquilon	120	2,000	25	.....	Normand	Building.
Averne	120	1,500	23.50	24.4	F. & C., Havre	
Ariel	120	1,500	23.50	.....	Normand	Do.
Chevalier	125	2,700	24.50	27.22	do	Rudder forward of propeller.
Cerbère	120	2.000	25	.....	F. & C., Havre	Building.
Corsaire	165	2,500	24.50	24.28	At. de la Loire	
Dauphin	120	1,500	23.50	.....	F. & C., Havre	
Dragon	120	1,400	20.50	25.03	Normand	Equipment weight, with coal, 32 tons.
Forban	125	3,260	30	.....	do	Building.
Flibustier	120	1,500	23.50	.....	do	
Grenadier	120	1,400	20.50	25.25	do	Equipment weight, with coal, 32 tons.
Lancier	120	1,400	20.50	25.79	do	Equipment weight, with coal, 32 tons; rudder forward of propeller.
Lansquenet	138	2,800	26	.....	Oriole	Returned to builders for alterations in machinery.
Mousquetaire	135	2,100	24.50	24.77	F. & C., Havre	
Tourmente	120	1,500	23.50	24.60	At. de la Loire	
No. 145	46	1,300	21	24.16	Normand	
146	46	1,300	21	24.26	do	
153	46	1,300	21	23.76	do	
154	46	1,300	21	23.15	do	
170	118	1,300	21	.....	do	Building.
171	118	1,300	21	24.38	do	
177	80	1,300	21	22.80	F. & C., Havre	
180	80	1,000	21	.....	Schneider	Do.
181	80	1,000	21	.....	do	Do.
182 to 187 (6)	80	1,000	23	.....	Normand	Do.
188 to 191 (4)	80	1,350	23	.....	F. & C., Havre	Do.

SUBMARINE BOATS.

GUSTAVE ZÉDÉ.

(Page 40, No. X.)

This submarine torpedo boat, which was launched in June, 1893, has had to undergo alterations and modifications in her accumulators for the past twelve months. In May, 1894, the boat caught on fire, presumably from a derangement of her accumulators, while being charged, and necessitated the sinking of the vessel. To repair the damages, it is reported, will cost 100,000 francs ($19,300). A few days before this accident the boat conducted a successful experiment. With a complement of 3 officers and 8 men on board the boat descended to a depth of 40 feet and remained there for about one hour and a half, communicating with the shore by means of a telephone.

GERMANY.

The German Naval Budget for the fiscal year ending March 31, 1895, amounts to a total of 73,922,974 marks ($17,593,667), a sum less by $1,550,000 than that voted for last year; $2,745,401 are appropriated for new construction and include payments on the following vessels of the building programme (p. 354, No. VIII): Battleship *Weissenburg*, sixth and final payment; battle ship *Kurfürst Friedrich Wilhelm*, sixth and final payment; coast-defense vessel *Hagen*, fourth and final payment; and also on the vessels included in last year's naval budget, viz: Cruiser *F*, second and final payment; *H*, second and final payment; torpedo vessel (torpedo division boat), second and final payment. A fourth and final payment on the coast-defense vessel *Heimdall*, and third payments on the coast-defense vessels *T* and *V*, were also voted.

For the ordnance and torpedo outfits for vessels under construction, a further sum of $409,360 was appropriated, and for the re-arming of the older vessels with rapid-fire guns and Maxim guns, a second and final payment of $436,000.

The appropriations asked, for one cruiser to replace the *Leipzig*, and one dispatch vessel to replace the *Falke*, were struck out in the Reichstag.

VESSEL PROPOSED OR LAID DOWN.

One battleship to replace the *Preussen*, the first payment being $238,000.

VESSEL LAUNCHED.

HAGEN (S).

(Page 354, No. VIII; 46, No. X.)

Coast-defense vessel; launched at Kiel October 18, 1893. The *Hagen*, which is the sixth vessel of the *Siegfried* type launched, differs in some particulars from her predecessors of the same type. The following par-

ticulars are from a German newspaper, published at the time of the launch:

Armament.—Three 24-centimeter (9.45-inch) Krupp guns; six 8.8-centimeter (3.4-inch) Krupp R. F. G.; four torpedo tubes, of which the bow tube has under-water discharge. The two bow 24-centimeter guns in the *Hagen* are mounted in barbette on the center line, and this arrangement is to obtain also in the remaining vessels of the type *T*, *U*, and *V*. The preceding vessels have these guns, separate, in barbette, two forward, one on each side, and one aft on the center line.

Protection.—Complete water-line belt of nickel-steel, 10.2 inches thick and 7 feet 4 inches wide; barbette armor, 8 inches; hoods, 4 inches to 5.5; complete protective deck, 1.5 inches thick.

Motive power.—The estimated horse-power is 4,800, and speed, 16 knots.

Dimensions.—Length, 239 feet; extreme breadth, 46 feet; greatest draught, 17 feet; displacement, 3,440 tons.

STEAM TRIALS.

WÖRTH.

(Page 354, No. VIII; 47, No. XI; 156, No. XII.)

On her official 6-hours' trial the *Wörth* developed a mean I. H. P. of 10,227, with a maximum of 10,700, the contract calling for 8,000 I. H. P. The Germania Shipbuilding Company thereby became entitled to a premium of 300,000 marks ($71,400).

The *Wörth* is one of the 4 battle ships of the building programme, and was launched on August 6, 1892. The following are her chief characteristics:

Armament.—Four 28-centimeter (11-inch) L/40 Krupp guns, in pairs, in the forward and after turrets; two 11-inch L/35 in the middle turret; six 10.5-centimeter (4.1 inch) R. F. G. in the superstructure; four 8.8-centimeter (3.4 inch) R. F. G. in sponsoned half turrets; four torpedo tubes in broadside with above-water discharge.

Protection.—Complete water-line belt of compound armor varying from 15 to 11.8 inches in thickness; the turrets, 11.8-inch nickel steel. The 4.1-inch and 3.4-inch R. F. G. are protected by 2-inch nickel-steel armor.

Dimensions.—Length between perpendiculars, 354 feet 4 inches; beam, 63 feet 11 inches; draught, 24 feet; displacement, 9,843 tons.

BRANDENBURG.

(Page 354, No. VIII; 48, No. XI.)

On the preliminary trial, on the passage from Swinemünde to Kiel, with natural draft, the engines developed 9,640 I. H. P., an excess over the contract requirements of 1,640; and with 110 revolutions per

minute, a speed of 16.5 knots was maintained. The engines worked very smoothly and without a hitch.

On February 16 the *Brandenburg* left Kiel to undergo the last of the series of steam trials previous to final acceptance. Steam was up in all 12 boilers, with natural draft, and the engines were indicating 7,000 horse power, when the main steam pipe of the starboard engine gave way, filling the engine and fire rooms with hot steam, and killing and wounding a large number of men.

KÖNIG WILHELM.

Battleship; after being completely refitted, the *König Wilhelm* made a speed of 19 knots on her trial, which is a little more than 5 knots better than her original speed.

KAISERIN AUGUSTA.

(Page 46, No. X; 48, No. XI.)

Protected cruiser of 5,960 tons; is said to have made over 20 knots for a number of consecutive hours, and developed over 12,500 I. H. P. The *Kaiserin Augusta* is the only vessel in the German navy using triple screws, and great interest has attached to the protracted trials to which she has been subjected to determine the comparative advantages of using 1, 2, or 3 screws. On the voyage from Germany to England, in the spring of 1893, she maintained a speed of 19 knots, using 3 screws.

HOHENZOLLERN.

(Page 47, No. X; 49, No. XI.)

On her 6 hours' trial, 9,460 I. H. P. was developed without employing forced draft, or 460 beyond the contract stipulations, and a speed of 22 knots realized instead of 21, as anticipated. During 24 hours' continuous steaming a mean speed of 19.5 knots was maintained.

The *Hohenzollern*, although built for an Imperial yacht, is armed and can, in case of need, be used as a fast cruiser or scout.

SEEADLER.

(Page 46, No. X; 49, No. XI.)

Unprotected cruiser; is said to have made 17 knots on her trial.

COMET.

Torpedo vessel; is stated to have maintained a speed of 22 knots for several consecutive hours.

VESSELS STRUCK FROM THE LIST.

Arminius, coast-defense vessel; *Friedrich Carl*, *Preussen*, and *Kronprinz*, battleships; *Luise*, unprotected cruiser. These vessels have been removed from the list of effective vessels.

TORPEDO BOATS.

No additional torpedo boats were appropriated for in the budget for this fiscal year.

In order to test the behavior at sea of the seagoing torpedo boats lately built by the F. Schichau Company, of Elbing, as well as to determine the effect upon the boilers of keeping up a full head of steam for a prolonged period of time, boats *S. 68* and *S. 69* were sent to sea in the face of a heavy gale on February 10, 1894. As the gale had been blowing on-shore for several days, the conditions were favorable for a thorough test of the seagoing qualities. The boats were brought down to the designed draught by taking on board an extra quantity of coal equal in weight to the torpedo outfit of actual service conditions, and left Wilhelmshaven at 9:30 a. m. The draught of *S. 68* was, forward, 4 feet 11 inches; aft, 8 feet 6 inches; of *S. 69*, forward, 5 feet; aft, 8 feet 8 inches. Although a rough sea was encountered at the Minsener Sand light-ship shortly after leaving the main channel, the speed of 16 knots was nevertheless maintained. At the Ausen Jade light-ship an unusually heavy ground swell was running and the revolutions were slowed down corresponding to a speed of 10 knots, the boats making capital weather of it. It was not even necessary to steer from aft, as the conning tower forward was habitable in spite of the seas. The engines worked well and smoothly, as the screws seldom were clear of the water, so that it was not necessary to throttle the steam in either boat.

The strength of the sea and wind may be judged from the fact that it took two hours to make the distance from the Ausen Jade light-ship to the whistling buoy (7.5 miles), and while this is not a great speed over the ground, it sets at rest any doubts as to the seaworthiness of boats of this class. The force of wind was put down on board as 10, while the shore stations at Wangeroog and Bremerhaven recorded a force of 11. At times *S. 69*, which was about 300 to 400 yards astern of *S. 68*, was entirely hidden by the seas.

The behavior of the boats underway having been sufficiently tested, they were slowed down and kept off in order to test them while lying to. During this evolution and while lying to with the wind two or three points on the bow, the boats behaved well and did not ship much water. The deck aft was quite dry. The boats were then run before it, a favorable time being chosen to bear up, and full speed, 16 knots, ordered, all hatches, etc., being battened down. Only one heavy sea came on board while falling off, but it was found necessary to go at full speed while scudding, as at 14 knots the sea came over the stern to the height of the after conning-tower gratings, nor did the boat steer as well as at 16 knots.

The results of the trial show that the boats are exceptionally valuable as seagoing torpedo boats; their handiness and manœuvring qualities,

under conditions of actual service, are also established, as is also their habitability in rough weather, such as must be counted upon in the North Sea at all seasons.

In all other types of boats it has been found necessary to keep a hand on the throttle constantly, and even then it is impossible to keep the screws from racing, the evil effect of which upon the physical systems of the occupants soon grows serious.

An examination of the boilers at the end of the trial showed them to be perfectly tight.

HAITI.

VESSELS LOST OR STRUCK FROM THE LIST.

Alexandre Pétion: Gunboat. Lost.

HOLLAND.

The Naval Budget for the fiscal year 1894–'95 amounts to a total of 15,619,355.64 florins ($6,278,980). The item for ship construction, including the purchase of materials, is $2,536,326, a decrease of $43,910 below that of last year. The sum asked for the building and equipment of new vessels, including ordnance and torpedo outfits, is $1,362,620, a sum less by $43,670 than that of last year, while for the repairs and fitting out of vessels already in commission $491,605 are appropriated, an increase of $13,889.

Work is to be continued on the three new coast-defense vessels begun last year; the firing trials for the armor of these vessels have been successful, and the armor is being prepared.

The Naval Budget for the Dutch East India colonies appropriates a total of 7,916,717 florins ($3,182,520), of which $1,169,173 are for the colonies' share toward the expenses of the mother country, and $2,013,346 for their own expenses. Included in the former sum are $428,934 for construction and materials, the same item for the colonial government, amounting to $586,840.

From the explanatory statement accompanying the estimates it appears that the naval force of the colonies consists of 21 vessels, with a total of 2,378 men and an auxiliary force of 4 vessels and 1,416 men, a total of 25 vessels and 3,794 men, of which 2,783 are Europeans.

VESSELS PROPOSED OR LAID DOWN.

GUNBOAT.

One new gunboat, only, is estimated for in the budget, but a building programme of some extent is under consideration.

PIET HEIN, EVERTSEN, KORTENÆR.

Of these coast-defense vessels, all named after celebrated admirals of the Dutch navy, the *Piet Hein* and *Evertsen* are building in private yards at Fijenoord and Vlissingen (Flushing), respectively, and the *Kortenær* in the navy-yard, Amsterdam.

The following are the principal features:

Armament.—Three 21-centimeter (8.27-inch) L/35 Krupp, and two 15-centimeter (5.9-inch) L/35 Krupp, B. L., six 75-millimeter (2.95-inch), and six 37-millimeter (1.45-inch) R. F. G., and three torpedo tubes. Two of the 8.27-inch guns are in a covered barbette turret forward and the third, carried aft, has only a gun shield. The 5.9-inch guns are placed in sponsons, one on each side, and have fore and aft fire. The six 2.95 inch (12-pounder) R. F. G. are carried on the superstructure deck, and the six 1.45-inch (1-pounder) R. F. G. are placed in the top of the military masts and on the bridge.

Protection.—Complete water-line belt, 5.9 inches thick; complete protective deck, 2.36 inches thick. The barbette armor is 9.45 inches thick.

Motive Power.—Beyond the fact that the vessels will have twin screws nothing is as yet known of their engines. The speed is to be 16 knots, and the coal capacity 250 tons.

Dimensions.—Displacement, 3,400 tons.

STEAM TRIALS.

REINIER CLAESZEN.

(Page 58, No. X; 55, No. XI.)

The 4 hours' full-power trial of this coast-defense vessel gave the following results:

I. H. P		2,032
Speed	knots	12.52
Revolutions, mean		178
Boiler pressure	pounds	151
Vacuum	inches	22.7–20.5
Air pressure	do	1.6–2.1

The *Reinier Claeszen* is a coast-defense monitor with low freeboard and ram bow. She was laid down in 1890 at Amsterdam, and launched in 1893.

Armament.—One 27-centimeter (8.27-inch) B. L. in a turret forward; one 17-centimeter (6.7-inch) B. L. on central pivot mount, aft; five R. F. G. and 2 above-water torpedo tubes.

Protection.—Compound belt 4.7 inches thick amidships and tapering to 3.9-inches. Revolving turret, compound armor, 11 inches thick. Conning tower 11 inches, and ammunition tube 3.9 inches. Protective deck complete, steel, .66-inch thick. There is a cellular belt for cellulose between the armor deck and berth deck at the sides.

Motive power.—Two vertical triple-expansion engines, cylinders 20, 31, and 50 inches in diameter, with a stroke of 19 inches. Three cylindrical steel boilers, with 2 furnaces in each; total grate surface, 110 square feet; total heating surface, 4,650 square feet.

The coal capacity at load draught is 90 tons.

Dimensions.—Length, 229 feet 7 inches; beams, 4 feet 3 inches; mean draught, 14 feet 5 inches; displacement at load draught, 2,490 tons.

BELLONA.

(Page 158, No. XII.)

The 4 hours' full-power trial of this vessel, which is used as an artillery school ship, gave, with 310 I. H. P., a speed on the measured mile of 8.72 knots.

Armament.—One 15-centimeter (5.9-inch) B. L.; seven 12-centimeter (4.7-inch) B. L. and 10 light B. L., 1.45 to 2.95 inches.

Motive power.—One vertical triple-expansion engine with cylinders 10.5, 17.5, and 28 inches in diameter and 19-inch stroke, designed to develop 350 I. H. P. The boiler is cylindrical, with a working pressure of 180 pounds per square inch; grate area 20 square feet; heating surface 737 square feet. Three-bladed Griffith propeller with pitch of 8 feet, changeable to 10.

Dimensions.—Length on load line, 170 feet; mean draught on trial, 11 feet 7 inches; displacement, 914 tons.

ZEEHOND.

This gunboat is reported to have made 11 knots on her trial.

BORNEO.

(Page 158, No. XII.)

The 4 hours' steam trial of this gun vessel took place in the Firth of Clyde on January 25, 1893, and gave the following results: Mean I. H. P., 1,040.5; revolutions, 209.6; air pressure, 0.7 to 1.2-inch; the mean speed over the measured mile was 13.225 knots; displacement on trial, 772 tons.

The *Borneo* was launched on November 25, 1892, at the yards of Messrs. J. & G. Thomson, Clydebank. Her topsides and framing are steel, but the bottom is constructed on the composite system with two thicknesses of teak planking bolted to the framing and sheathed with copper. The vessel has a complete installation of electric lights.

Armament.—Six 10.5-centimeter (4.1-inch) B. L. and six small guns.

Protection.—A splinter deck of steel over the machinery space; coal protection along the whole length of the machinery space, also below the splinter deck, alongside the boilers.

Motive power.—One vertical, triple-expansion engine, with cylinders 17, 26.5. and 41 inches in diameter, and stroke of 18 inches. Two

cylindrical boilers with 2 furnaces each, having 59.5 square feet of grate surface and 1,950 square feet of heating surface. Three-bladed manganese-bronze Griffith propeller, 9 feet in diameter, with adjustable blades, which on the trial had a pitch of 6 feet 9 inches.

Dimensions.—Length on load-water line, 166 feet; extreme breadth of beam, 31 feet; mean draught on trial, 11 feet; displacement at load draught, 817 tons.

ITALY.

The naval estimates submitted in November, 1893, by the minister of marine for the fiscal year beginning July 1, 1894, amounted to 99,877,897 lire ($19,277,534.12), but the reductions effected by Admiral Morin, the new minister of marine, have enabled him to present new estimates, which amount to 95,870,411 lire ($18,502,989.32), and which sum has been passed (May, 1894) by the Chamber, after an animated discussion. This is a decrease of 8,014,972 lire ($1,546,889.60) from the appropriations of the previous year.

The amount set apart for new construction and for vessels building is 25,000,000 lire ($4,825,000), being the same as for the previous year.

VESSELS PROPOSED AND LAID DOWN.

The new construction proposed in accordance with the above appropriations comprises: 2 battleships of the *Emanuelo Filiberto* type (p. 158, No. XII); 1 protected cruiser of the *Calabria* type (p. 343, No. VIII); 1 armored cruiser of the *Carlo Alberto* type (p. 158, No. XII); 2 torpedo vessels of the *Partenope* type (p. 343, No. VIII).

PUGLIA.

A protected cruiser of the *Lombardia* type (p. 343, No. VIII) has been laid down in the Government yard at Taranto. It is reported that she will have a displacement of 2,500 tons.

GIUSEPPE GARIBALDI (A), VARESE (B).

The two armored cruisers provided for in the budget for 1893–'94 have been named as above. The former is being constructed by Messrs. Ansaldo & Co., at Sestri Ponente, near Genoa, and the latter by the Orlando Bros., at Leghorn. These vessels are of the *Carlo Alberto* type (p. 158, No. XII), and will have a displacement of 6,840 tons. They are the third type of armored cruisers referred to on p. 42, No. XI.

VESSELS LAUNCHED.

CAPRERA (CLIO).

(Page 343, No. VIII; 42, No. XI.)

This torpedo vessel, originally named *Clio*, was launched by Orlando Bros., at Leghorn, in May, 1894. She is an improved *Partenope* (p. 343,

No. VIII), and having a high topgallant forecastle, will be a good sea boat.

Armament.—One 12-centimeter (4.7-inch) R. F. G.; four 57-millimeter R. F. G.; two 37-millimeter R. C., and five torpedo tubes, one fixed in the bow and two training in each broadside.

Protection.—Complete steel deck, 1 inch thick.

Motive power.—Triple-expansion engines, driving twin screws, to develop 4,000 I. H. P., and give an estimated speed of 19 knots.

Dimensions.—Length between perpendiculars, 229 feet 7 inches; beam, 27 feet 5 inches; mean draught, 10 feet 2 inches; displacement, 853 tons.

GOVERNOLO.

(Page 41, No. XI.)

This unprotected cruiser was launched at Venice in May, 1894. The vessel is intended for service on foreign stations, and has a coal bunker capacity of 200 tons.

Armament.—Four 12-centimeter (4.7-inch) R. F. G.; four 57-millimeter R. F. G.; two 37-millimeter R. C.; and two machine guns.

Motive power.—Engines driving a single screw and developing 1,000 I. H. P., natural draft, and estimated to give a speed of 15 knots.

Dimensions.—Length, 185 feet; beam, 33 feet 7 inches; mean draught, 13 feet 8 inches; displacement, 1,255 tons.

STEAM TRIALS.

UMBRIA.

(Page 343, No. VIII; 43, No. X.)

On April 23, 1893, this vessel underwent her official natural-draft trial of six hours' duration at sea, giving a mean speed of 17.5 knots, with 4,487 I. H. P. The consumption of coal was 1.6 pounds per horse-power per hour, the contract allowing 2 pounds. The contract requirements are 4,000 I. H. P., natural draft, and 6,500 I. H. P. under forced draft.

On May 21, 1894, the official forced-draft trial of three hours' duration took place, giving a mean speed of 19 knots and 7,105 I. H. P. The consumption of coal was 1.78 pounds per horse power per hour, the contract permitting the use of 2.42 pounds.

SARDEGNA.

(Page 42, No. X.)

This vessel, one of the largest Italian battle ships, 14,210 tons, and one of the most formidable vessels afloat, commenced her preliminary trials in June, 1893.

The contract required a development of 15,200 I. H. P. under natural draft and 22,800 I. H. P. under forced draft.

On June 14, 1893, on preliminary trial, with 12,000 I. H. P., a speed of 19 knots was obtained for 1 hour, and 20 knots for a few minutes. It is reported that the vessel was not loaded down to her normal draught, having neither guns nor stores on board.

On May 5, 1894, the official natural-draft trial of 3 hours' duration took place in a smooth sea, the displacement being 13,950 tons. The results gave a mean speed of 19.06 knots and a mean I. H. P. of 14,150.

On May 16, 1894, a preliminary modified forced-draft trial of 2 hours' duration gave a mean speed of 20 knots and 17,500 I. H. P. An accident to the ventilating machinery interrupted further trials, and the official forced-draft trial will take place as soon as the necessary repairs are made.

The successful use of petroleum as a fuel has been demonstrated aboard this vessel.

RE UMBERTO.

(Page 43, No. X.)

This vessel was placed in active service before the completion of her steam trials, and upon the completion of the summer manœuvres in 1893 the vessel again resumed her official trials. The following account of the trial of October 25, 1893, is from the *Italia Marinara:*

> The engines worked satisfactorily, developing a mean I. H. P. of 17,000 without material increase of air pressure in the fireroom. The temperature in the engine room and fire room was moderate. The sea was smooth, and the course was from Spezia to Portofino and return. During three consecutive hours a mean speed of 18.2 knots was maintained, the maximum during this period being 18.5 knots.
>
> The ship steaming at the rate of 18.5 knots per hour, turned through 180 degrees in 3 minutes 38 seconds, the greatest heel during the evolution being 2.5 degrees.
>
> The contract calls for 15,200 I. H. P. with natural draft and 19,500 with forced draft, and the trial just completed shows that these results can be obtained easily.

The results were considered so satisfactory from every point of view, both as regards the speed of the vessel and the facility with which the speed could be maintained (the trial being made by the ship's crew and not by special firemen) that the commission recommended the navy department to accept the machinery without further trials, it appearing obvious that the horse power under forced draft would exceed the contract of 19,500. This recommendation was accepted by the minister of marine.

ETRURIA.

(Page 43, No. X.)

This vessel completed her official steam trials in the last months of 1893. The speed on the measured-mile course was 20 knots per hour, the mean H. P. under forced draft was 7,500 and the maximum 7,800. The contract requirements for this vessel are 6,500 I. H. P. and 18.5 knots speed, forced draft.

JAPAN.

The budget, as passed by the Congress in 1893, appropriated yens 11,339,055.84 ($5,680,866.97), of which yens 4,921,437 ($2,465,629.91) are for construction, to be expended as follows:

	Yens.
(1) Building of vessels commenced in 1891	1,819,002
(2) One battle ship, to commence in 1893	2,148,614
(3) One cruiser and one dispatch vessel, to commence in 1893	953,821
Total	4,921,437

The estimates for 1894–'95 are reported to be exactly the same as those for last year, owing to the dissolution of the Japanese Parliament.

VESSELS PROPOSED OR LAID DOWN.

The shipbuilding programme for 1894 includes two battle ships, one protected cruiser, and one dispatch vessel.

FUJI YAMA.

Negotiations were concluded in May, 1894, with the Thames Iron Works, Blackwall, England, for the construction of one of the battle ships, and which has been named as above. The ship will be of the *Royal Sovereign* type (*see* Steam Trials, England) and have a displacement of 12,250 tons.

It is reported that the other battle ship will be built by Sir W. G. Armstrong, Mitchell & Co., of Elswick, England.

CRUISERS.

In March, 1893, the keel was laid at the Government yard, Yokosuka, for a protected cruiser as provided for in the above estimates. The vessel is to be of the English *Apollo* type (*see* Steam Trials, England) and it is estimated that she will be completed in 1896.

Armament.—Two 6 inch and six 4.7-inch Armstrong R. F. G., and twelve 3-pounder R. F. G.

Protection.—Steel deck complete, 2 inches on the slopes and 1 inch on the flat.

Motive power.—Triple-expansion engines of 8,000 I. H. P. to drive twin screws, giving an estimated speed of 20 knots.

Dimensions.—Length, 306 feet 9 inches; beam, 40 feet; displacement, 2,700 tons.

A protected cruiser was laid down at the Yokosuka navy-yard in May, 1894. She is a sister ship in all essential features to the cruiser laid down at the same yard in March, 1893.

DISPATCH VESSEL.

The dispatch vessel, authorized to commence in 1893, was laid down at Kuré, the Japanese Government yard, in the spring of 1894.

Armament.—Eight R. F. G., four R. C., and two torpedo tubes.

Motive power.—Engines of 6,000 I. H. P.

Dimensions.—Length, 304 feet 6 inches; draught, 13 feet; displacement, 1,800 tons.

VESSELS LAUNCHED.

TATSUTA.

A steel torpedo vessel, named *Tatsuta*, was launched in April, 1894, by Sir W. G. Armstrong, Mitchell & Co., at Elswick, England. It is estimated that she will be completed in August, 1894.

Armament.—Two 4.7-inch Armstrong R. F. G., four 3-pounder Hotchkiss R. F. G., and 5 torpedo tubes. The torpedo tubes are arranged in two pairs of twin tubes, one on each broadside and one fixed tube firing right ahead.

Motive power.—Vertical triple expansion engines of 5,000 I. H. P., driving twin screws, and giving an estimated speed of 21 knots.

Dimensions.—Length, 240 feet; beam, 27 feet; displacement, 850 tons.

STEAM TRIALS.

AKITSUSHIMA.

(Page 159, No. XII.)

This vessel was completed at Yokosuka in April, 1894. As yet there has been no forced-draft trial, but six preliminary trials have been made under natural draft, lasting about 6 hours each. A speed of 16 knots was obtained.

YOSHINO.

(Page 56, No. XI.)

This vessel's official forced-draft trial was noted on p. 159, No. XII, but further details are here given by reason of the remarkably high speed attained, viz, 23.08 knots as the mean of 4 runs over the measured mile. As has already been noted, the *Yoshino* belongs to the same class of vessels as the *Piemonte* (Italy), *Veintecinco de Mayo*, and *Nueve de Julio* (Argentina), all built by Sir W. G. Armstrong, Mitchell & Co. The *Yoshino* exceeds all of these in size and speed and is regarded as an improved *Nueve de Julio.*

In the disposition of the armament (p. 56, No. XI) one 6-inch gun is placed on the forecastle and one on the poop, each having an arc of 270 degrees. The other two 6-inch guns are placed in sponsons, one in each bow, arc of fire 150 degrees, and giving a concentration of three 6-inch guns right ahead. These sponsons are constructed in such a manner that it is calculated they will not catch the sea and cause the ship to be wet.

On July 18, 1893, the vessel ran for 6 hours under natural draft, with

a mean speed of 21.6 knots, the contract requiring 21 knots. The vessel was also tested for turning powers, and it is reported that she completed a circle of 375 yards diameter in 3 minutes 8 seconds. The helm was put hard a-starboard from hard a-port in 15 seconds.

VESSELS LOST OR STRUCK FROM THE LIST.

Asama, sailing corvette, has been converted into a torpedo training ship. *Kasuga*, paddle dispatch vessel, has been converted into a training ship for the torpedo class, with headquarters at the torpedo station, Yokosuka. *Fuji Yama*, sailing ship, broken up. *Tisima*, or *Chisima*, torpedo vessel, lost by collision. November, 1892.

NORWAY.

TORPEDO BOATS.

VARG (No. 8). RAKET (No. 9).

Second-class torpedo boats launched at Christiania May 17, 1894. They are of the same type, and have each 2 over-water tubes, one in the bow and one amidships, on training carriage. They have triple-expansion engines; one of them is supplied with Thornycroft water-tube boilers, built in Norway, and the other has du Temple boilers, made in France. Length, 111 feet 6 inches; beam, 12 feet 4 inches; displacement, 43 tons.

RUSSIA.

As finally passed the total Russian naval budget for the fiscal year 1894–'95 amounts to 51,231,393 roubles ($21,158,565), the value of the rouble at that time being 41.3 cents, an increase of $552,837 over that of last year. Of this sum the items for naval construction amount to $8,384,164, an increase of $154,164.

Work is to be continued on the following vessels: Battle ships *Sessoi Veliki*, *Tri Sviatitelia*, *Petropaulovsk*, *Sebastopol;* coast-defense vessels *Admiral Oushakoff*, *Admiral Senjavin*, and the armored cruiser *Rossia*.

VESSELS PROPOSED OR LAID DOWN.

The following are the new vessels provided for in the budget:

SESSOI VELIKI NO. 2, ROTISLAW.

Battle ships of the *Sessoi Veliki* type. The former is to be laid down at the New Admiralty Works, St. Petersburg, on the slip where the original was built. The latter is to be laid at the navy-yard, Nikolaieff, on the slip from which the *Tri Sviatitelia* was launched,

GRAND ADMIRAL APRAXINE.

Coast-defense vessel, similar to the *Admiral Oushakoff;* to be built in the Baltic.

RURIK NO. 3.

(Page 161, No. XII.)

Armored cruiser to be laid down at the New Admiralty Works, on Galernia Island, St. Petersburg, as soon as one of the vessels under construction there is launched.

TORPEDO VESSELS.

Two torpedo vessels, *Vsadnik* type, to be built at Abo, by Messrs. Creighton & Co.

TRANSPORTS.

To gradually replace the schooners now used at Revel, with vessels of modern type, it has been decided to order two transport steamers, one to be built in England and one in Sweden. They are to cost about $250,000 apiece.

STEAMER.

One steamer for use in the Black Sea was contracted for in July, 1893, with the firm of Burmeister & Wain, Copenhagen, to be delivered in May, 1895. She is to be of the following dimensions: Length, 370 feet; beam, 90 feet; displacement, 5,557 tons.

STANDARD.

A royal yacht of about 4,000 tons displacement has been ordered in Copenhagen. The machinery and boilers are to be furnished by Messrs. Humphrys, Tennant & Co., England. She is to carry an armament of R. F. G., and in time of war will probably be available as a dispatch vessel.

VESSELS LAUNCHED.

SESSOI VELIKI.

(Page 45, No. XI.)

Battle ship, launched June 2, 1894.

The following are the characteristics of this type. They have a high freeboard, 2 smoke pipes, and 2 masts, of which one is a military mast with 2 armored tops, and the other a signal mast. The complement is 32 officers and 550 men.

Armament.—Four 11.8-inch guns in pairs in revolving turrets, one forward and one aft, on the center line; six 5.9-inch R. F. G., in broadside in a central casemate; twenty 1.8-inch and 1.4-inch R. F. G.; six torpedo tubes, one forward, one aft, and two on each broadside.

Protection.—Complete water-line belt 15.7 inches thick for four-fifths of the length and 11.8 inches along the rest of the water line, surmounted by a broad and complete belt of 5-inch armor for the casemate. Complete steel protective deck 3 inches in thickness. The forward turret has 11.8 inches, the after one 10.2 inches of armor, and the transverse bulkheads are 11.8 inches thick.

Motive power.—Twin screws, driven by vertical triple-expansion engines of 8,000 I. H. P., in the aggregate, fed by 16 cylindrical boilers placed in groups of 4 in separate water-tight compartments. Speed, 16.5 knots, with forced draft. Bunker capacity, 800 tons, which, at a speed of 10 knots, will give a steaming radius of 2,000 knots.

Dimensions.—Length, 344 feet 6 inches; beam, 68 feet 10 inches; displacement, 8,800 tons.

ADMIRAL OUSHAKOFF.

(Page 160, No. XII.)

Coast-defense vessel, launched November 8, 1893. This vessel was built at the Baltic Works, St. Petersburg, where her keel was laid in June, 1892; the material is domestic steel, the stem and stern-post being cast steel. The armor for sides, bulkheads, and glacis was made at Ijor (Kolpino), and at Aboukoff.

Armament.—Four 10-inch L/45, B. L., in pairs, in armored barbettes on the center line; four 12-centimeter (4.7-inch) R. F. G., of new model, one at each corner of the casemate; twenty-four Hotchkiss and Baranoff guns; four torpedo tubes.

Protection.—Water-line belt 176 feet in length and 10 inches thick, backed with teak; protective deck 2.5 inches, barbette armor 8 inches.

Motive power.—Triple-expansion engines, driving twin screws, and designed to develop 5,000 I. H. P., with natural draft, giving a speed of 16 knots; the engines and boilers were built by Messrs. Maudsley & Field, in England. Bunker capacity, 260 tons. Total coal capacity, 400 tons.

Dimensions.—Length on water line, 277 feet 6 inches; extreme breadth of beam, 52 feet; draught, 17 feet; displacement, 4.126 tons.

GRIEDYEN, GUIDAMAK, AND VSADNIK.

(Page 160, No. XII.)

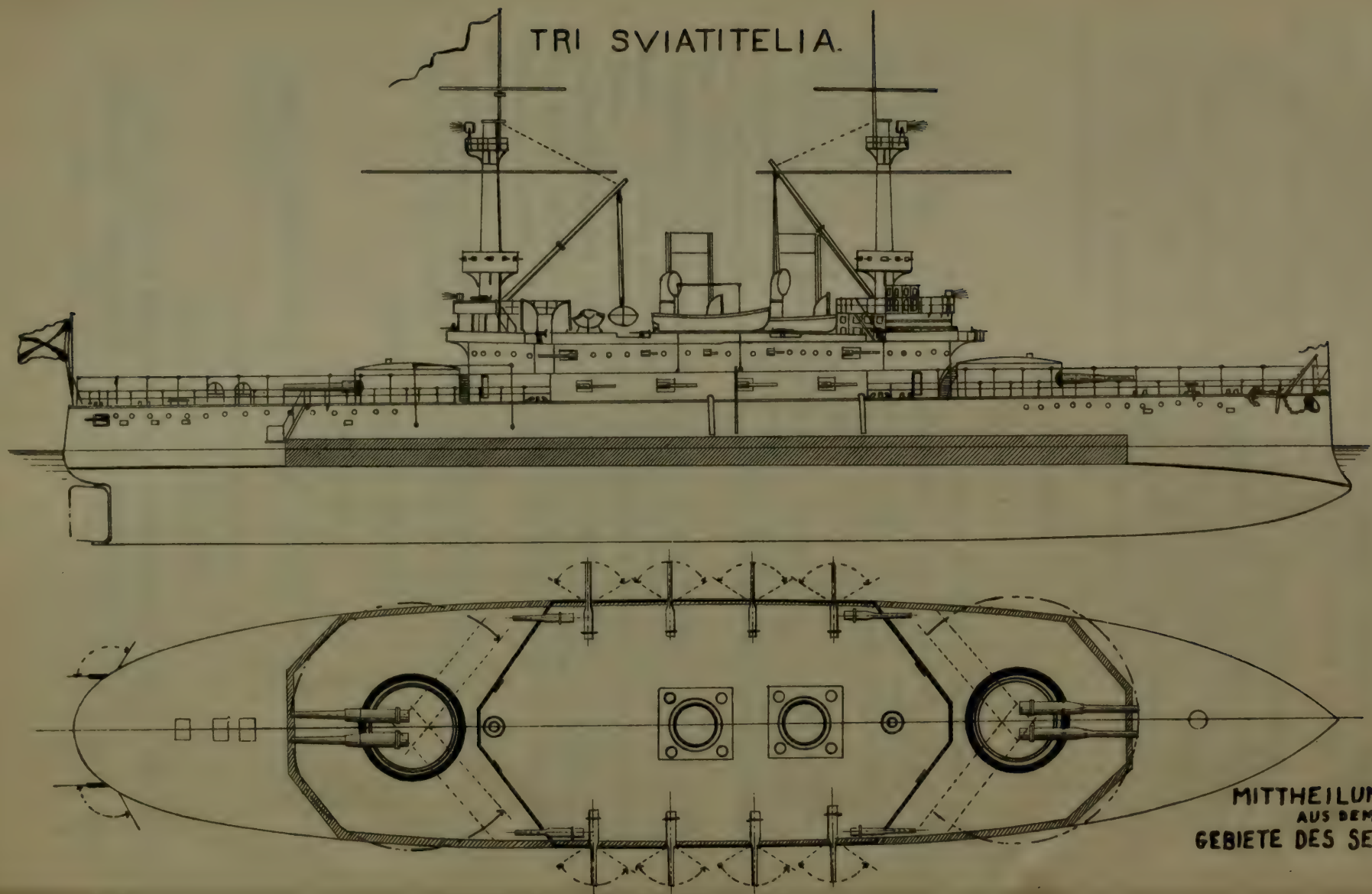
Torpedo vessels of *Kazarski* type. (*See* description of *Woewoda* under Steam Trials.)

TRI SVIATITELIA (*Three Saints*).

(Page 44, No. X; 160, No. XII.)

The launch of this battle ship took place at the navy-yard Nikolaieff in December, 1893, and not, as erroneously reported, in July.

The design of the *Tri Sviatitelia* was evolved by the Russian



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technical committee, of which Chief-Constructor Ratnik is the head, and follows in general that of the English battle ship *Trafalgar* (p. 305, No. VII), although a number of alterations has been introduced from time to time during her construction. The most important are the use of nickel-steel for armor, the increase of the number and caliber of the guns of the auxiliary battery, and the substitution of Canet 6-inch R. F. G. for the 4.7-inch of the *Trafalgar*. An armored and covered superstructure has been added for the protection of the auxiliary battery and electric training gear provided for the heavier guns and turrets. The living space has been greatly increased and improved systems of ventilation and drainage introduced. The vessel has a double bottom for two-thirds of her length and a longitudinal central bulkhead extending through the engine and boiler space; there are also side longitudinal bulkheads abreast the boilers and engines for protection against torpedoes, and numerous transverse water-tight bulkheads extending up to the berth deck; there are in all 215 water-tight compartments.

There are 2 smoke pipes and 2 masts with military tops carried very low, and 4 search lights, 2 of which are carried at the mastheads. The main engines and boilers were built by Messrs. Humphrys, Tennant & Co., London, the turret fittings and hydraulic machinery in St. Petersburg, and the armor was furnished by Messrs. Vickers, Sons & Co., England, and the Creusot and St. Chamond Works, France.

Armament.—Four 30.5-centimeter (12-inch) L/40 Aboukoff guns in pairs in two turrets forward and aft; eight 15-centimeter (6-inch) L/45 Canet R. F. G. in broadside within the superstructure; four 12-centimeter (4.7-inch) R. F. G. at the corners on the upper deck of the superstructure; ten 3-pounder R. F. G. on the upper deck of the superstructure; forty-two other machine and R. F. G., of which probably ten will be in each top; two 6.3-centimeter (2.5-inch) Baranoff boat guns. There will be six torpedo tubes, one fixed in the bow under the main deck, one fixed in the stern, and two training in each broadside, of which two of the latter may have under-water discharge. The total weight of ordnance and ammunition is 912 tons.

Protection.—The water-line belt 250 feet long is from 16 to 18 inches thick and begins about 60 feet abaft the stem; it is 7 feet 10 inches wide, extending 4 feet 11 inches below the water line. Above the water-line belt the side armor, 16 inches thick, protects the bases of the turrets, the engines and boilers, forming, together with the transverse bulkheads, 16 and 14 inches thick, an elliptical casemate 218 feet in length, fore and aft. The octagonal casemate, which rises above this, and which contains the 6-inch Canet R. F. G., has 5 inches of nickel-steel armor. The protective deck armor is 2 inches thick, increased to 3 inches at the extremities beyond the diagonals. The weight of the armor is 4,012 tons. The turrets, 30 feet in diameter, are protected by 16 inches of nickel-steel; the conning tower is 12 inches thick.

Motive power.—Triple-expansion engines driving twin screws and designed to develop with forced draft, 10,600 I. H. P., giving a speed of 16 knots.

Total coal capacity 1,000 tons. With full supply of coal on board, the steaming radius at 16 knots is calculated to be 1,840 knots, or 4 days 19 hours steaming; at 10 knots, 3.980 knots, or 16 days 4 hours steaming.

Dimensions.—Length over all, 377 feet 4 inches; length between perpendiculars, 370 feet 8 inches; extreme breadth of beam, 73 feet; draught on loadline, 26 feet 11 inches; displacement, 10,600 tons. The freeboard is 11 feet forward and the height of the upper deck 27 feet above the water.

STEAM TRIALS.

IMPERATOR NICOLAÏ I.

(Page 267, No. VI; 353, No. VIII.)

The following are the results of a 6 hours' trial of this battle ship on July 12, 1892: I. H. P., 8,400; speed, 14.5 knots; revolutions, 97; boiler pressure, 112–125 pounds; vacuum, 26 inches. The mean of 4 runs on the measured mile gave 14.85 knots.

The *Imperator Nicolaï I*, which was laid down in July, 1886, and launched June 1, 1889, has a single revolving turret forward on the center line, and a central armored redoubt rising from the protective deck, recessed forward and aft, so as to permit bow and stern fire from the 4 forward and after guns respectively of the broadside battery. There is a high superstructure amidships around the smoke-pipes, and a light bridge over the conning tower. The vessel is built of steel, sheathed with wood and coppered, has a strong ram bow, and is brig rigged.

Armament.—Two 12-inch B. L. in the turret, with train of 240 degrees; four 9-inch B. L. in broadside in the armored redoubt, of which two fire ahead and two astern, with arc of fire of 110 degrees; eight 6-inch B. L., four in the redoubt, between the 9-inch guns, and four outside in the bow and stern, with an arc of fire of 110 degrees; ten 3-pounder R. F. G., and ten machine guns; six torpedo tubes, one in the bow and one in the stern, fixed; two in each broadside, training, all with over-water discharge. Two search lights.

Protection.—Complete water-line belt, compound, 14 to 8 inches thick, extending from 5 feet above to 3 feet 2 inches below the water line; transverse bulkheads 6 inches, splinter bulkheads 1 inch; complete steel protective deck, 2.75 inches thick. The turret, which is 20 feet 6 inches in diameter, is protected by 10 inches of compound armor; the conning tower is 6 inches thick.

Motive power.—Triple-expansion engines, designed to develop 8,500 I. H. P. Estimated sea speed, 15 knots.

Dimensions.—Length, 326 feet; breadth, 67 feet; mean draught, 23 feet; displacement, 8,440 tons.

DVENADSAT APOSTOLOFF (*Twelve Apostles*).

(Page 44, No. X; 44, No. XI.)

On her 6 hours' trial in October this battle ship developed a mean of 7,280 I. H. P. and a corresponding mean speed of 15.6 knots.

On October 21, 1892, on a second trial, she made 16.6 knots, with a mean of 8,000 I. H. P. On this trial the engines were not pushed to their maximum power (8,500) to obtain the estimated speed of 17 knots, as the quality of the coal was poor and it was not deemed wise to risk injury to the boilers by using forced draft. During her service in the fleet in the summer of 1893 she was accounted capable of making a maximum speed of 16 knots in service.

The *Dvenadsat Apostoloff* is a central casemate ship and was launched at Nicolaieff in September, 1890. She has two masts, of which the fore has a military top, and two smoke pipes.

Armament.—Four 12-inch L/35 Krupp Aboukoff B. L., mounted in pairs in covered barbettes on the center line near the extremities; the cupola shields are 3 inches thick. Four 6-inch, L/35, mounted in the corners of the casemate, the sides of the hull being recessed to permit fore-and-aft fire. Twelve 3-pounder R. F. G., six on the casemate deck and six on the superstructure above the casemate. Fourteen 1-pounder R. F. G. on the upper deck and in the top. There are six torpedo tubes with over-water discharge, one fixed in the stem, one in the stern, four training, in broadside. Two projectors, one carried at the masthead.

Protection.—The armor is compound, and consists of a belt 212 feet long, 16 inches thick abreast the engines and 14 inches abaft and forward of them; it extends 1.5 feet above and 4 feet below the water line. Above the water-line belt is a side-armor belt 14 to 12 inches thick, extending up to the casemate deck. The bulkheads at the ends of the lower belt are 12 inches thick; those at the ends of the side-armor belt somewhat less. The central casemate, containing the 6-inch guns, has an all-around protection of 5 inches. The armor of the barbettes is 10 and 12 inches thick, and that of the conning tower 10 inches. The protective deck before and abaft the belt is 2.5 inches; over the belt and citadel, 2 inches thick.

Motive power.—Two vertical triple-expansion engines, placed in 2 separate compartments and driving twin screws. They were designed to develop 8,500 I. H. P. with natural draft and 11,500 with forced draft, and give a speed of 16 and 17.5 knots, respectively. There are 8 boilers, of which 4 are single and 4 double-ended.

Dimensions.—Length, 330 feet; breadth, 60 feet; mean draught, 25 feet 6 inches; displacement, 8,000 tons.

The complement is 530, all told.

OTVAJNY.

(Page 44, No. X; 46, No. XI.)

Armored gunboat; is reported to have made a speed of 13 knots.

The *Otvajny* is a sister ship to the *Gremiastchy* and *Grosiastchy* (p. 45, No. X), and was launched in May, 1892. The hull resembles somewhat the U. S. S. *Boston* in appearance, and is well subdivided into water-tight compartments. The living and storeroom spaces are spacious. There are 2 light masts and one smoke pipe.

The following are the particulars of the class:

Armament.—One 9-inch Krupp in forward superstructure. One 6-inch B. L. aft, on deck. Four or six 3-pounder R. F. G. on superstructure and bridge. Two 37-millimeter H. R. C. on superstructure. Two torpedo tubes, fixed, with over-water discharge, one in the stem and one in the stern. One search light.

Protection.—Water-line belt extending around the stern and to within about 30 feet of the stem. Amidships, in wake of the boilers and machinery, the belt is 5 inches thick, tapering to 3.5 at the stern and to 4 inches forward. Transverse bulkhead, 3.5 inches, joining the ends of the belt. Protective deck, 1 inch.

Motive power.—Triple-expansion engines, driving twin screws and designed to develop 2,000 I. H. P., with a speed of 13 knots. Six Belleville boilers. Coal capacity, 130 tons.

Dimensions.—Length on load-water line, 223 feet 6 inches; beam, 41 feet 7 inches; draught, 11 feet; displacement, 1,492 tons.

SILATCH.

(Page 45, No. XI.)

Torpedo supply vessel; has been completed and commissioned. She has a raised forecastle and a long deck house surmounted by a chart house, two pole masts, and presents the appearance of a private yacht.

Armament.—Four 37-millimeter H. R. C.

Motive power.—The engines are said to be of 1300 I. H. P., giving a speed of 12 knots.

Dimensions.—Length, 157 feet; beam, 27 feet 6 inches; draught, 13 feet; displacement, 750 tons.

WOEWODA, POSADNIK.

(Page 44, No. IX; 160, No. XII.)

The results of the trials of these torpedo vessels were most satisfactory.

Duration of trial.	Revolutions per minute.	I. H. P.	Coal per hour.
Hours.			*Pounds.*
1	220	3,600	4.766
1	200	2.798	3.813
2	180	2,012	2.445
2.5	160	1,278	1.715
4.5	120	534	.957
3	90	234	.404

The mean speed obtained was 22.4 knots, the contract calling for 21 knots. The coal consumption on the forced draft trial was 1.543 pounds per indicated horse power per hour.

These vessels are both of the *Kazarski* type (p. 39, No. IX); they have the appearance of large torpedo boats with perfectly straight rails and very fine lines. The deck is flush except for a forecastle about 10 feet long. There are two slender masts and one large smoke pipe.

Armament.—Five 3-pounder and four 1-pounder R. F. G.; two torpedo tubes, one fixed in the bow and the other on a turn table just abaft the smoke pipe; one search light on the bridge.

Protection.—The engines and boilers are protected by coal bunkers on all sides.

Motive power.—One triple-expansion engine designed to develop 3,500-horse power, and supplied with steam from two locomotive boilers. The total weight of the machinery is 128 tons. The coal capacity with full bunkers is 90 tons, which, at a speed of 14 knots, would drive the vessel 3,500 knots.

Dimensions.—Length, 190 feet 3 inches; beam, 24 feet 3 inches; draught aft, 10 feet; displacement, 400 tons.

VESSELS LOST OR STRUCK FROM THE LIST.

Russalka, coast-defense vessel, lost; *Vitiaz*, partially protected cruiser, lost; *Gornostai*, gun vessel, struck from list.

TORPEDO BOATS.

In the naval budget for this year provision is made for 8 new boats, of which 2 will be of the *Anacria* type and 6 of the *Pernov* type.

It has recently been stated in a number of service journals, that 28 boats of the first class were to be laid down this year, but these do not appear in the estimates. It is also stated that the Russian Government has ordered one torpedo boat of *Havock* type from Messrs. Yarrow, of England, to have a speed of 29 knots. If successful it will be reproduced in Russia.

A recent article in *La Vie Contemporaine* gives the following as the number of torpedo boats of the Russian navy:

Baltic fleet, 121 first and second class boats, of which 27 have a speed of from 19 to 25 knots. Black Sea fleet, 23 first and second class boats, of which 16 have a speed of from 18 to 22 knots. Siberian and Caspian flotilla, 10 second-class boats; completing, 5 first-class boats, making a total of 159.

The Russian torpedo boats are of two types, Schichau and Normand, with the preponderance of numbers in favor of the former.

ASPEN, TRANSUND, TOSNA, DOMESNESS.

These boats are copies of the Schichau boat *Anacria* (p. 39, No. IX) and were built, the first two at the Ijor Works, Kolpino, and the others at the Putiloff works, St. Petersburg.

The following are the principal characteristics of the type: Length on water line, 127 feet 11 inches; breadth, 15 feet 8 inches; draught, aft, 6 feet 8 inches; displacement, 98 tons. They have each a single triple-expansion engine, the cylinders being 16.5, 24.8, and 24.8 inches in diameter, with stroke of 16 inches. The boilers are the du Temple type, made in France. The estimated horse power is about 1,100 and speed 21 knots.

SESTRORETSK.

(Page 160, No. XII.)

The torpedo vessel mentioned as building in France turns out to be a torpedo boat. She is of the 36-millimeter (118 feet) Normand type, similar to the French boats *No. 170* and *No. 171*, and is to have a speed of 24 knots. On her trial one of her boiler tubes burst, wounding three men, and the trial had to be postponed.

SPAIN.

The naval appropriations for 1893–'94, as authorized by royal decree of August 5, 1893, amount to 22,503,410.62 pesetas ($4,343,158.25).

VESSELS PROPOSED OR LAID DOWN.

The three torpedo vessels (p. 162, No. XII) are modified *Filipinas* (p. 162, No. XII), and their keels were laid in January, 1894, at Ferrol, by the firm of Sr. Vila y Cia. It is reported that they are to have a displacement of 850 tons and a speed of 20 knots. It is also reported that the Government has decided to increase the naval force by building 23 gunboats, 15 of which are to be of 500 tons displacement and 8 of 150 tons displacement. A number of these boats is intended for service on the Cuban coast.

The following small gun boats have been added to the Spanish navy and were placed in coast-guard service in 1893: *Cuervo*, of 71 tons displacement; *Aquila*, 72 tons displacement; *Perla*, 36 tons displacement; *Diamente*, 42 tons displacement; *Rubi*, 42 tons displacement.

STEAM TRIALS.

INFANTA MARIA TERESA.

(Page 318, No. VII; 355, No. VIII; 42, No. IX; 51, No. X.)

This vessel completed her contract steam trials off Ferrol in September and October, 1893, with satisfactory results. The speed under natural draft for 6 hours was 18.5 knots, and under forced draft for 4 hours, 20.24 knots.

The following details of the official trials are from the London *Engineering:*

Infanta Maria Teresa. Official trials at Ferrol.

	Natural draft, Sept. 18, 1893.	Forced draft, Oct. 14, 1893.	Coal consumption, Oct. 18, 1893.
Revolutions per minute	107	118	55
Indicated horse power:			
Starboard high-pressure cylinder	1,592	2,069	259.38
Starboard intermediate-pressure cylinder	1,553	2,290	211.38
Starboard low-pressure cylinder	1,487	2,460	120.14
Port high-pressure cylinder	1,626	2,075	273.65
Port intermediate-pressure cylinder	1,606	2,515	190
Port low-pressure cylinder	1,635	2,313	176.65
Total	9,499	13,722	1,231.2
Steam pressure ... pounds	140	143	110
Vacuum:			
Starboard ... inches	27	27.5	26.5
Port ... do	27	27	27
Receivers:			
Starboard high pressure ... pounds	117	134	33
Starboard intermediate pressure ... do	36	52	3
Starboard low pressure ... do	7	13	9.5 inches vacuum
Port high pressure ... do	112	140	34
Port intermediate pressure ... do	38	50	2
Port low pressure ... do	7	15	10 inches vacuum
Mean pressure:			
Starboard high pressure ... do	46.2	54.4	14.7
Starboard intermediate pressure ... do	20.7	27.6	5.5
Starboard low pressure ... do	9	13.5	1.42
Port high pressure ... do	47.2	54.6	15.45
Port intermediate pressure ... do	21.4	30.4	4.9
Port low pressure ... do	9.9	12.7	2.08
Cut-offs:			
High pressure ... per cent	62.5	73	55
Intermediate pressure ... do	70	75	60
Low pressure ... do	70	75	67.5
Speed ... knots	18.5	20.24	10
Duration of trials ... hours	6	4	10

Mean air pressure in fire rooms at forced draft trial=1 inch of water. Coal consumption per indicated horse power per hour=650 grams=1.43 pounds.

The following are the results of the turning trials:

Rudder.	Speed.	Diameter of turning circle.
Degrees.	*Knots.*	*Yards.*
20	10	1,540
30	10	940
20	16	1,040
35	16	840

The contract further stipulated for a trial with one screw, the rudder being thrown over to maintain a straight course, and the guaranteed speed being 12 knots. This trial, under natural draft, was run on October 19. The port engine was used, the rudder being from 12 to 15 degrees over. The mean speed of 3 runs on the measured mile was 12.56 knots, with the engine running at 85 revolutions. Steam was supplied from 1 single-ended and 2 double-ended boilers.

On the same day the starting, stopping, and reversing trials were gone through with the following results: From "full speed ahead" to "stop," 7 seconds; from

"full speed astern" to "stop," 6 seconds; from "full speed astern" to "full speed ahead," 7 seconds.

The contract also stipulated for a trial of the engines to ascertain the least number of revolutions required to enable the engines to work with perfect regularity with the valves sufficiently closed, with the normal vacuum in the condenser, and with 145 pounds boiler pressure. This proved to be 13 revolutions, equal to a speed of ship of about 2.5 knots. At this speed the engines were kept running for about, 10 minutes.

The following particulars of the vessel are given:

Armament.—Two 28-centimeter (11-inch) B. L., one forward and one aft, mounted in barbette turrets; ten 14-centimeter (55-inch) R. F. G.; two 7-centimeter (2.75-inch) R. F. G.; eight 57-millimeter Nordenfelt, R. F. G.; two 11-millimeter machine guns; eight Hotchkiss R. C., and eight torpedo tubes.

Protection.—An armor belt 12 inches thick, 5 feet 6 inches broad, and extending for a distance of 315 feet amidships and having a backing of teak 6 inches thick; a complete protective deck 2 inches thick on the flat and 3 inches on the slopes. The two barbettes, which are within the extremities of the belt, have armor 10 inches thick, and the ammunition tubes, above the protective deck, are protected by steel armor plates 8 inches thick. Coal bunkers are arranged in the wake of boilers and machinery. The vessel has a double bottom and 11 transverse bulkheads.

Motive power.—Two sets of vertical, triple-expansion engines driving twin screws; diameter of cylinders 42, 62, and 92 inches, stroke 46 inches. There are 4 double-ended and 2 single-ended boilers. In addition there are 2 separate boilers for the auxiliary machinery comprising over 50 separate engines which are located in the engine and boiler compartments.

The vessel has a bunker capacity of 1,000 tons.

Dimensions.—Length, between perpendiculars, 340 feet; greatest beam, 65 feet 2 inches; mean draught at normal displacement, 21 feet 6 inches; displacement, 6,890 tons.

MARQUÉS DE LA ENSENADA.

(Page 43, No. IX.)

It is reported that a forced-draft trial of this vessel in January, 1894, gave a maximum speed of 17 knots.

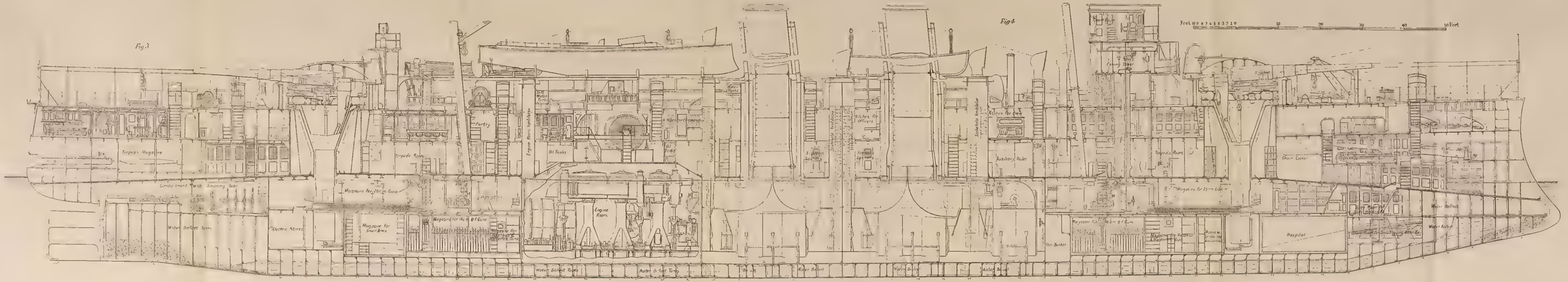
SWEDEN.

The total naval estimates for the present fiscal year amount to 9,781,260 crowns ($2,621,370), of which $670,000 are for new construction.

In the estimates presented to the Diet by the finance minister, provision is made for the increase of the Swedish navy, now composed of some 60 vessels, many of which, however, are of old types.

"INFANTA MARIA TERESA."

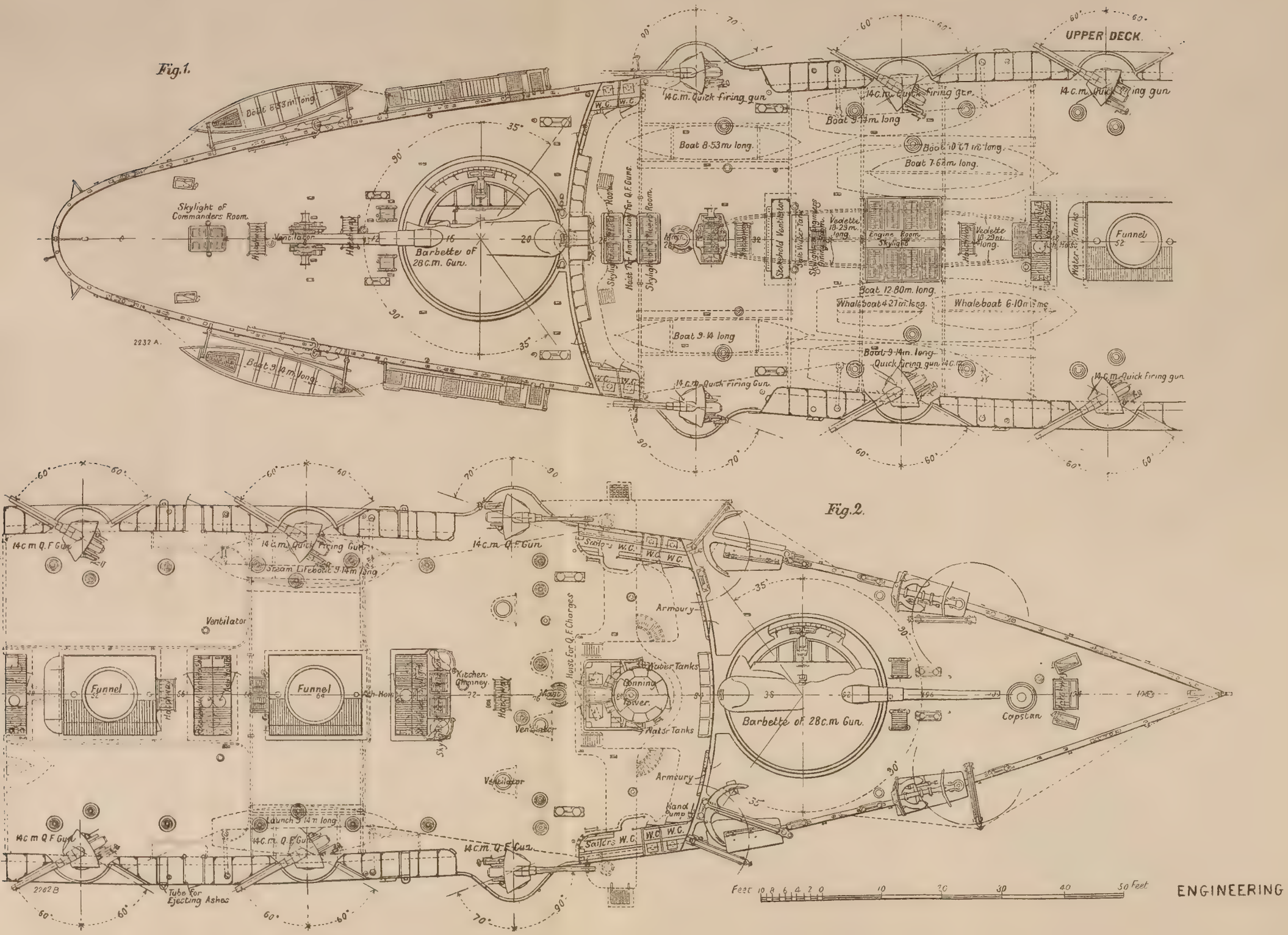
CONSTRUCTED AND ENGINED BY LA SOCIEDAD ANONIMA DE LOS ASTILLEROS DEL NERVION, BILBAO.



ENGINEERING

"INFANTA MARIA TERESA."

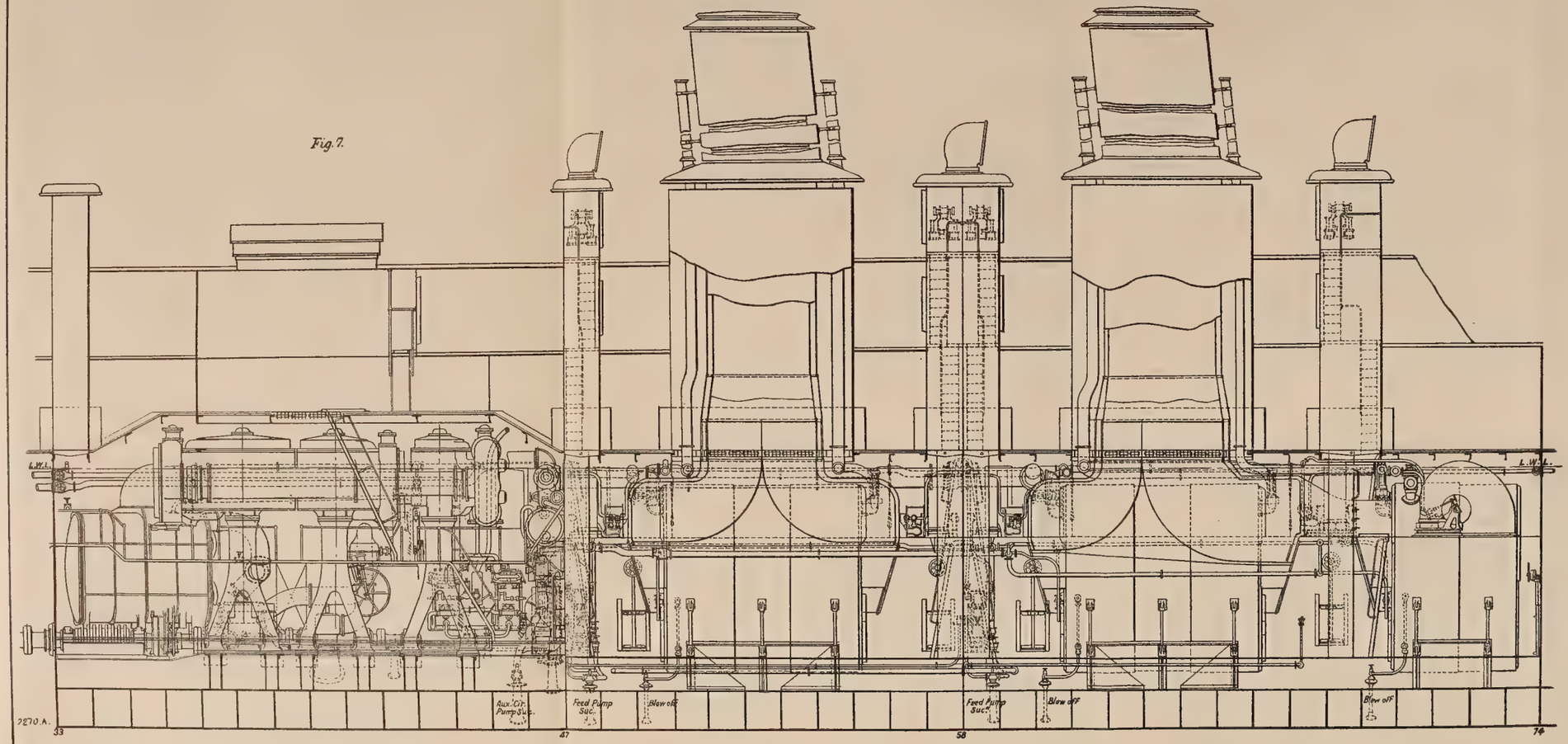
CONSTRUCTED AND ENGINED BY LA SOCIEDAD ANONIMA DE LOS ASTILLEROS DEL NERVION, BILBAO.

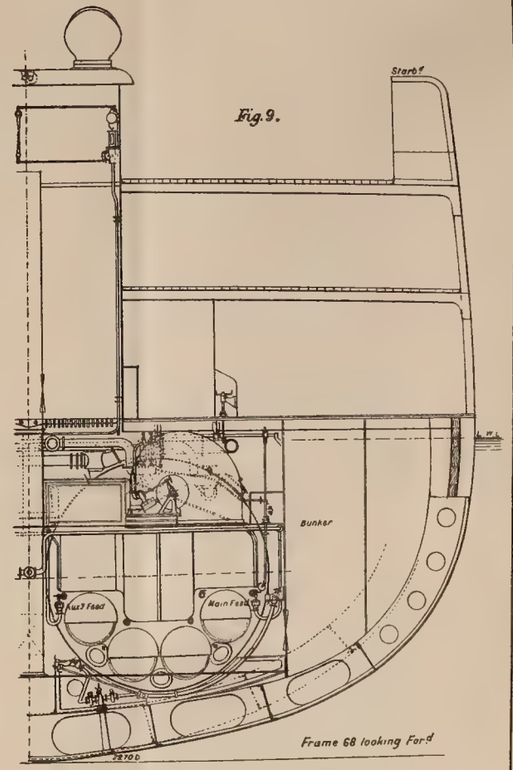


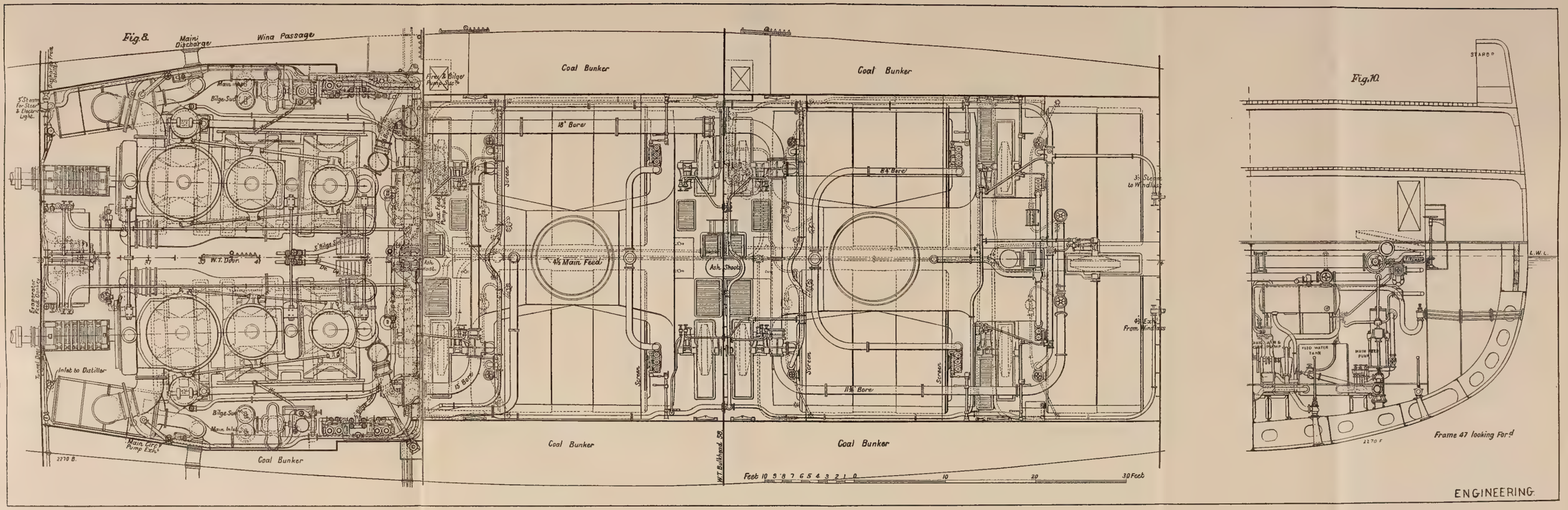
ENGINEERING

GENERAL ARRANGEMENT OF THE MACHINERY OF THE SPANISH CRUISER "INFANTA MARIA TERESA."

CONSTRUCTED BY LA SOCIEDAD ANONIMA DE LOS ASTILLEROS DEL NERVION, BILBAO.







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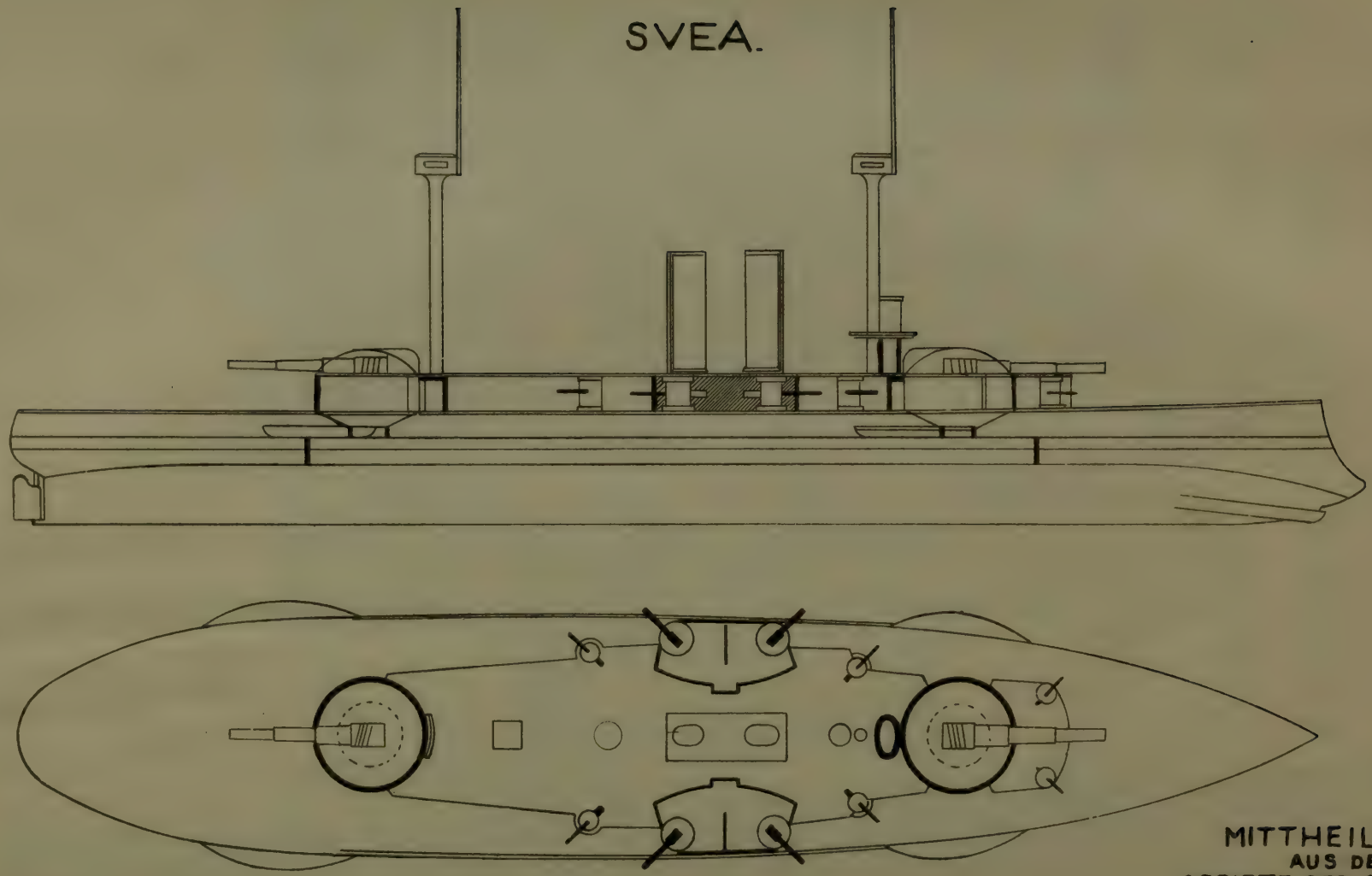


MITTHEILUNGEN
AUS DEM
GEBIETE DES SEEWESENS.

A plan is proposed involving a calculated outlay of 10,622,000 crowns ($2,846,696), and extending over a period of five years. This amount is expected to cover the following items:

VESSELS PROPOSED OR LAID DOWN.

ARMORED COAST-DEFENSE VESSELS.

Three are to be built similar to the *Thule* (p. 212, No. V; 57, No. XI; 162, No. XII), the payments being spread over the years 1894 to 1899.

The protected cruiser (p. 162, No. XII) for which a first payment was voted in the estimates for 1893–'94 turns out to be an additional coast-defense vessel of the *Svea* type, improved. The following particulars are from official sources:

Armament.—Two 25-centimeter (9.84-inch) Armstrong B. L. in two turrets, forward and aft; four 12-centimeter (4.7-inch) R. F. G. in broadside, in armored casemates; six 6-pounder R. F. G., two on each side forward and abaft the 4.7-inch guns and one on either side of the 9.84-inch gun in the forward turret; ten 25-milimeter machine guns. There will be one torpedo tube for 15-inch torpedoes under the ram.

The ammunition supply is estimated as follows: 80 rounds for the 9.84-inch guns; 110 rounds for the 4.7-inch guns; 250 rounds for the 6-pounders.

Motive power.—The engines are designed to develop 3,700 I. H. P., giving a speed of 15 knots.

Dimensions.—Length on water line, 270 feet; greatest breadth, 48 feet; maximum draught, 17 feet; displacement, 3,403 tons.

DISPATCH VESSEL.

One dispatch vessel is asked for, to be completed in 1896.

TRANSPORT.

One transport is included in the programme, to be laid down in 1896 and completed in 1897.

TORPEDO BOATS.

The naval programme includes 16 torpedo boats, of which 10 are of the first-class and 6 of the second. It is proposed to build 1 first-class boat in 1896, 3 first-class and 2 second-class boats in 1897, 3 first-class and 2 second-class boats in 1898, and 3 first-class and 2 second-class boats in 1899.

TURKEY.

VESSELS PROPOSED OR LAID DOWN.

TORPEDO VESSEL.

A torpedo vessel is building at Kiel for the Turkish Government. It is to be ready before the end of the year.

Armament.—Two 10.5-centimeter (4.13-inch) R. F. G.; six 3-pounder R. F. G.; three torpedo tubes with over-water discharge, one fixed in the bow and two in broadside.

Dimensions.—Length (about), 246 feet; beam, 27 feet 10 inches; displacement, 850 tons.

III.

NOTES ON ORDNANCE.

By Lieut. E. F. Qualtrough, U. S. Navy.
Staff Intelligence Officer.

GUNS AND MOUNTS.

Leading authorities agree that the naval artillery of the future will be of moderate dimensions; and this opinion is based on several important considerations. The endurance of guns diminishes as the caliber increases. The machinery required for the manipulation of very large guns may easily be disabled by a projectile from a comparatively small gun. As guns of abnormal size can only be fired at intervals of several minutes the practice is necessarily very uncertain against swiftly moving ships. The employment of guns of moderate weight paves the way for valuable improvements in speed, coal endurance, protection, reduction of displacement, and increase in the number of ships and guns for a given outlay.

The maximum limit of dimensions for naval guns should depend on the work required to be done, and if the penetrating power is sufficient to successfully attack the thickness of armor likely to be encountered it is better to increase the number of guns than to add to their size.

The projectile thrown by the latest type of 12-inch gun is capable of perforating any armor yet afloat at fighting ranges, and a formidable bursting charge may be carried.

Some experts are advocating the adoption of a 10-inch gun of increased length and power as the heaviest weapon to be mounted on board ships. The weight of such a gun is estimated at about 35 tons; a velocity of 3,000 foot seconds is recommended, and an improved system of rifling is to be used.

Manufacturers of rapid-firing guns have been increasing the size and power of their productions, and devoting particular attention to perfecting the mounts and ammunition.

Important as have been the advances in the designs of guns they are hardly of greater value than the improvements made in gun mounts.

An efficient mount has many important duties to perform, one of the principal ones being to provide an effective means of absorbing the energy of the recoiling gun. The introduction of the hydraulic system for accomplishing this result has proved so successful that it will undoubtedly be some time before any other system supersedes it.

By arranging for the recoil to take place in the line of fire the "jump" is much reduced and sudden blows to the deck are obviated, although a severe strain is necessarily brought upon it from the recoil press. Springs have been generally introduced for returning guns to the firing position. They were first used with the mounts for rapid-firing guns, and the experience thus obtained has led to their more extended employment. The adoption of the system of "live rollers" has made it practicable to train large mounts, carrying heavy shields, by hand. Shields have been increased in thickness, and in some cases the system of an inner and outer shield has been adopted, together with steel traverses between the guns wherever practicable. Nickel steel is being introduced as a material for shields.

Sights are now usually fitted on the mount, so that the pointing shall not be interfered with by the loading or firing of the gun.

ENGLAND.

Placing the supply of naval ordnance under the control of the Admiralty has resulted in a marked improvement in naval armaments, and a strong effort is being made to replace all the obsolete guns with the latest patterns of modern ordnance, even in the older types of ships.

According to the navy estimates for 1894–'95 the actual expenditure under the naval defense acts, 1889 and 1893, for armaments for dockyard built ships to 31st March, 1893, is £1,766,206 ($8,594,458); the anticipated expenditure for 1893–'94–'95 is £641,794 ($3,122,986); for contract-built vessels the actual expenditure for armaments for the same period is £1,302,849 ($6,339,663.33); the anticipated expenditure for 1893–'94–'95 is £372,420 ($1,812,196.02); the further programme for armaments not under the naval defense acts is £577,000 ($2,847,682); making a total expenditure for armaments of £4,660,269 ($22,676,869).

The explanatory statement of the first lord of the Admiralty contains the following remarks on the subject of ordnance:

The progress of gun manufacture has been very satisfactory this year, and the guns are ready for all the ships arming or about to be armed under the naval defense act. Two hundred and ninety-eight guns have been completed, varying from 16.25 inch to 4.7 inch, the greater number being of the 6-inch rapid-firing type, of which 169 are ready and most of them mounted.

The first of the new 12-inch steel wire-wound guns has been completed and proved, and it is now with the ordnance committee for experiment to ascertain the best form of chamber and rifling to be used with cordite. Five more of these guns are in an advanced state of construction. The new 4-inch rapid-firing gun has been

completed. The same may be said of the 12-pounder rapid-firing ship gun, of which a large number have been ordered for the torpedo boats.

Cordite has been approved and adopted for rapid-firing guns of 6-inch and lesser caliber.

Included in one of the recent designs for a first-class cruiser are 12-inch rifled howitzers, having a length of 13 calibers and intended to fire shells filled with Lyddite.

WIRE-WOUND GUNS.

Leading authorities in England expect wire to take a prominent place in future gun construction.

The present system of wire construction at Woolwich is substantially as follows:

The A tube is in two parts, called the inner and outer A tube, the inner one being also known as the "liner." The liner is in one piece, and is about 1 inch thick at the muzzle and 1.2 inches over the chamber. Upon the exterior surface are a number of steps of about one-fourth inch each, which allow for the increase in size for the formation of the chamber at its rear end, and fit the liner closely to the A tube. It is intended to cut out the liner when it becomes necessary to replace it after unscrewing the bush that is screwed into the A tube, and in which the breech plug works.

With spare liners ready it is expected that a 12-inch gun may be relined in about two months.

The A tube proper is in one piece and is about 2 inches thick at the muzzle and about 1.25 inches thick over the chamber. There are steps on the outside of the proper size to take 4-inch, 6-inch, or 8-inch thickness of wire. Upon this tube the wire is wound at tensions varying from 56 to 32 tons per square inch, having a breaking strain of 110 tons per square inch and an elastic limit of 75 to 80 tons per square inch. On top of the wire is a closely fitting steel jacket, which gives additional strength, relieves somewhat the longitudinal strain on the A tube, protects the wire from abrasion and cutting by small caliber projectiles, and adds to the weight of the gun. The outer surface of the wire is made smooth before the jacket is put on.

The wire is wound from the muzzle to the breech and back. Wherever there is a jog or an increase in the thickness of the wire, a band is put on, and in winding back, this band becomes a new point of departure. The bands hold the wire in place and prevent it from stripping or breaking up at these points. A band is also put on at the point where the wire stops, at about a foot from the muzzle, and another at the rear end of the chamber, where the wire stops at the breech end. The outer covering is in two parts, the jacket over the after portion of the gun and the B tube over the forward part. The jacket covers the breech and chamber, and the B tube continues from it to the muzzle.

These two main portions of the covering are supplemented by the saddle band and the breech-locking ring.

The jacket goes on over the muzzle and is shrunk on, fitting into the jogs made by the wire in rising over the chamber. It extends to the end of the breech and is flush with the rear end of the A tube, the wire, as already stated, stopping near the rear end of the chamber.

The B tube then goes on over the muzzle and is shrunk on, with its after end abutting close against the forward end of the jacket. It fits closely over the muzzle, its inner surface filling up the space at the muzzle end left by stopping the wire a foot short of the end of the A tube, and its outer surface forms the bell-shaped swell of the muzzle end. There is a jog on the outer surface of the B tube near its junction with the jacket.

The saddle band is put on over the muzzle, and is turned into its place cold. It has a thread on its after inner circumference that fits a thread on the forward end of the jacket, and it has a jog on its forward inner circumference that takes with the jog on the outer surface of the B tube. When turned into place this band tends to hold the B tube firmly in place against the jacket.

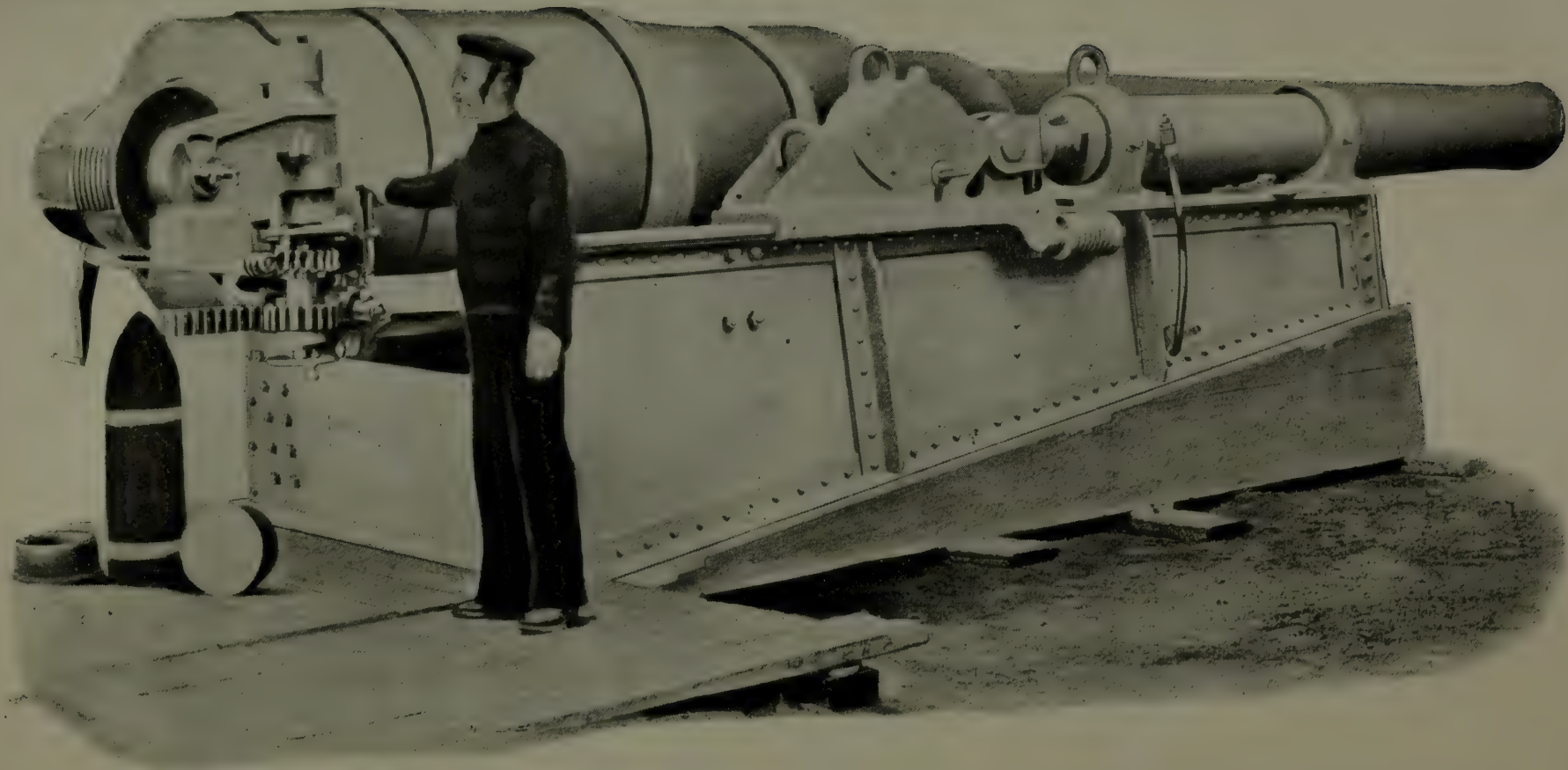
The breech-locking ring next goes into place, and fills up all the space between the rear end of the jacket and the end of the A tube. Its outer circumference has a thread turned upon it that works into a corresponding thread on the inner circumference of the rear end of the jacket. Its inner surface butts up against the A tube, and its forward end takes against the band that terminates the rear end of the wire, and also against the jogs in the A tube, thus binding and locking together all parts of the gun.

There are also sixty 6-inch wire-wound R. F. G. in course of construction at Woolwich.

The charge for the 12-inch wire-wound gun is expected to be about 168 pounds of cordite made up in quarter charges. The cordite used is to be in solid sticks 14 inches long and one-half inch in diameter. The estimated cubical contents of the chamber is about three times the charge.

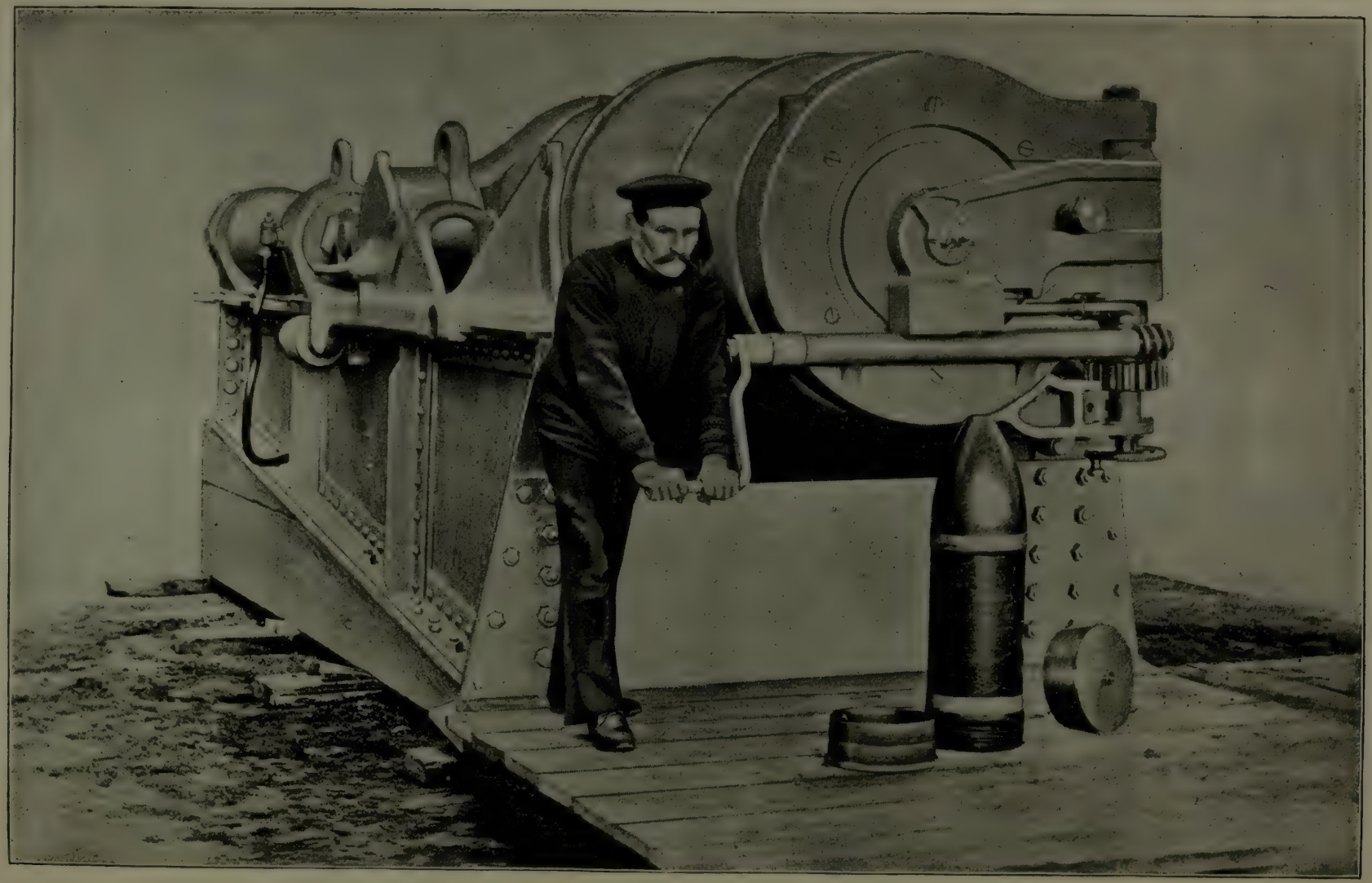
The result of the explosion of this charge is said to be so pure a gas that the scoring in the gun will be very slight, though the washing away of the metal for four or five calibers from the seat of the projectile is expected to be considerable. Should cordite prove unsatisfactory, the chamber of the 12-inch gun will be reamed out and a charge of 440 pounds of brown powder will be used.

Experiments recently made with cordite in a gun having a smooth bore some distance from the seat of the projectile demonstrated that grooves parallel to the axis of the bore for the same distance would be preferable.



10-INCH B. L. GUN FITTED WITH AUTOMATIC BREECH MECHANISM, SHOWING THE BREECH OPEN WITH MAN IN THE ACT OF WITHDRAWING THE LEVER TO THROW THE AUTOMATIC GEAR INTO ACTION FOR CLOSING.

Artillery Its Progress and Present Position.



10-INCH B. L. GUN FITTED WITH AUTOMATIC BREECH MECHANISM, SHOWING THE HAND-GEAR IN ACTION.

Artillery. Its Progress and Present Position.

ELSWICK AUTOMATIC BREECH MECHANISM.

It is desirable that, if possible, the only pauses in firing shall be due to the operations of aiming. This condition of affairs has been attained by guns up to 8 inches in caliber, and the automatic breech mechanism is an effort to realize it with the heavier guns. The recoil of the gun, after firing, is utilized to diminish the time required for loading, and also to reduce the number of men required to work the gun. The results so far obtained have been so satisfactory that the Admiralty have ordered its adoption for the 12-inch guns which are to form the principal armament of future battle ships. The Italian Government has also ordered this system fitted to several 10-inch guns. Even where hydraulic machinery is used the operations of opening and closing the breech occupy about a minute, whereas, with the automatic gear these operations require only about 6 seconds, and, as the opening is accomplished while the gun is running out, nothing is added to the time required for loading. Hand mechanism is also provided and can be thrown into gear in a moment.

The gun shown in the cut is mounted on an old proof carriage.

The gearing consists of (1) a horizontal rack and pinion, the latter borne on the carrier shaft and connected with the breechblock by a knuckle-jointed rod; (2) a cylinder carrying a spring and bolted to the inside of the chassis in the prolongation of the rack; (3) the case of a sliding block, in which there is a vertical slot, shown upon the face of the breech. This block engages a stud at the lowest point of the breechblock, first disengaging the latter, and then swinging it open, the connection with the rack and pinion being made by the knuckle-jointed rod.

The gun being fired, recoils and carries with it the rack engaged by the pinion on the carrier shaft, and compresses the spring in the cylinder. At the end of the recoil the rack is held where it is by a bolt dropping into a detent in it, and the gun in moving forward into battery starts the pinion on the rack and the rod connecting the latter with the sliding block first disengages the breechblock and then swings it open.

When the gun is loaded the lever is moved, releasing the bolt from the detent, setting the powerful spring in the cylinder in operation, moving the rack forward and closing the breech by the reversal of the opening process.

The obturation is performed by means of short cartridge cases, which perform their function admirably.

NEW ELSWICK MOUNT FOR 9.2 AND 10 INCH GUNS.

In the new mount for 9.2 and 10 inch guns elevation can be obtained up to 40 degrees. A peculiar arrangement of the shield allows the gun port to be made very small, though the possible angular movement of the gun is so large.

The front thickness of the shield is 6 inches and the inclined part of roof is 4 inches, which is expected to deflect projectiles as heavy as 50 pounds in weight.

The recoil presses are fitted with valve keys and with adjustable controlling rams. The slides are horizontal, so that firing at great elevation may not cause too severe a downward blow. After recoil the gun is run out by helical springs.

In order to reduce friction and so facilitate elevation the trunnions are provided with knife edges which rest on steel bars. By means of adjusting screws one end of each bar may be raised.

The elevating arc on the gun is of unusual width, and two pinions engage it. One of these, carried on a hollow shaft, is driven by the elevating gear, and provides the means for elevating or depressing the gun. The other pinion is attached to a rod, which passes through the hollow shaft of the elevating pinion and works the gun sights.

It is claimed that one man can move the gun through an arc of 47 degrees in 25 seconds.

Some details of the mounts for the heavy guns of the *Centurion* and *Barfleur*, as fitted by Sir Joseph Whitworth & Co., are as follows:

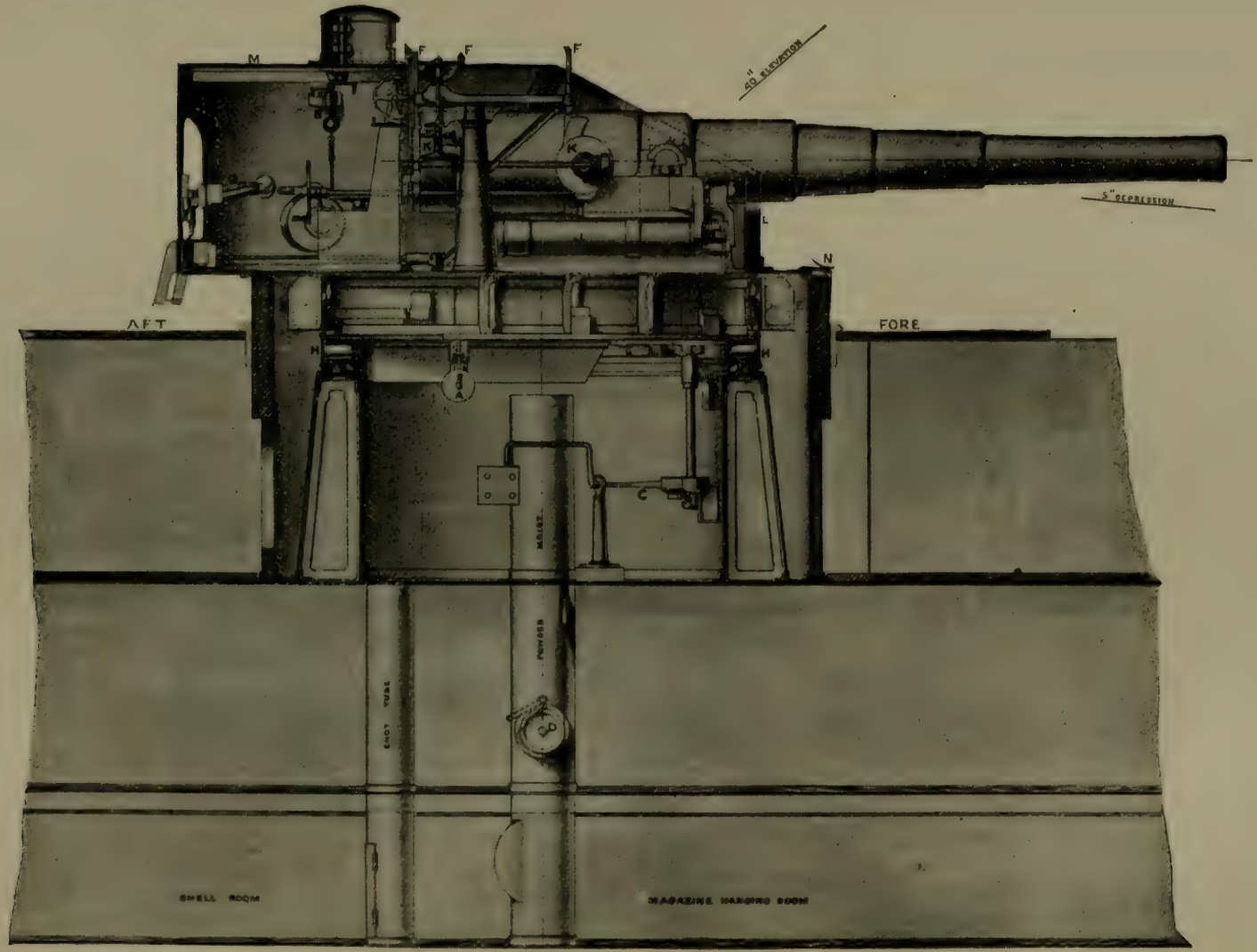
The 29-ton guns are mounted in pairs upon armored barbettes, which spring direct from the armored deck. The turntable upon which the guns revolve is detached from this armored redoubt, the roller path for the rollers of the turntable being mounted upon a circular steel wall 14 feet high, within the redoubt and concentric with it. Suspended from the turntable and revolving beneath it inside the walls which support the roller path, is a cylindrical shell chamber, 16.5 feet in diameter and 8 feet high, which contains 60 projectiles in racks. Through the center of all, and rising direct from the main magazine and shell room to the revolving shell chamber is an ammunition trunk circular in shape and 4 feet 3 inches in diameter. It is divided by a vertical net, one side being for the power-worked ammunition cage, actuated by a combined steam and hydraulic hoist, and the other side for a cage worked by a hand winch which can be used whenever desired. Both deliver into the shell chamber while the guns are in any position of training. Inclined hoists, worked by hand, from the platform above the turntable, bring up the ammunition from the shell chamber to the breech ends of the guns.

The mounts admit of an elevation of 35 degrees and depression of 7 degrees. Elevation is accomplished by hand, a hand wheel being worked from a platform beside the gun.

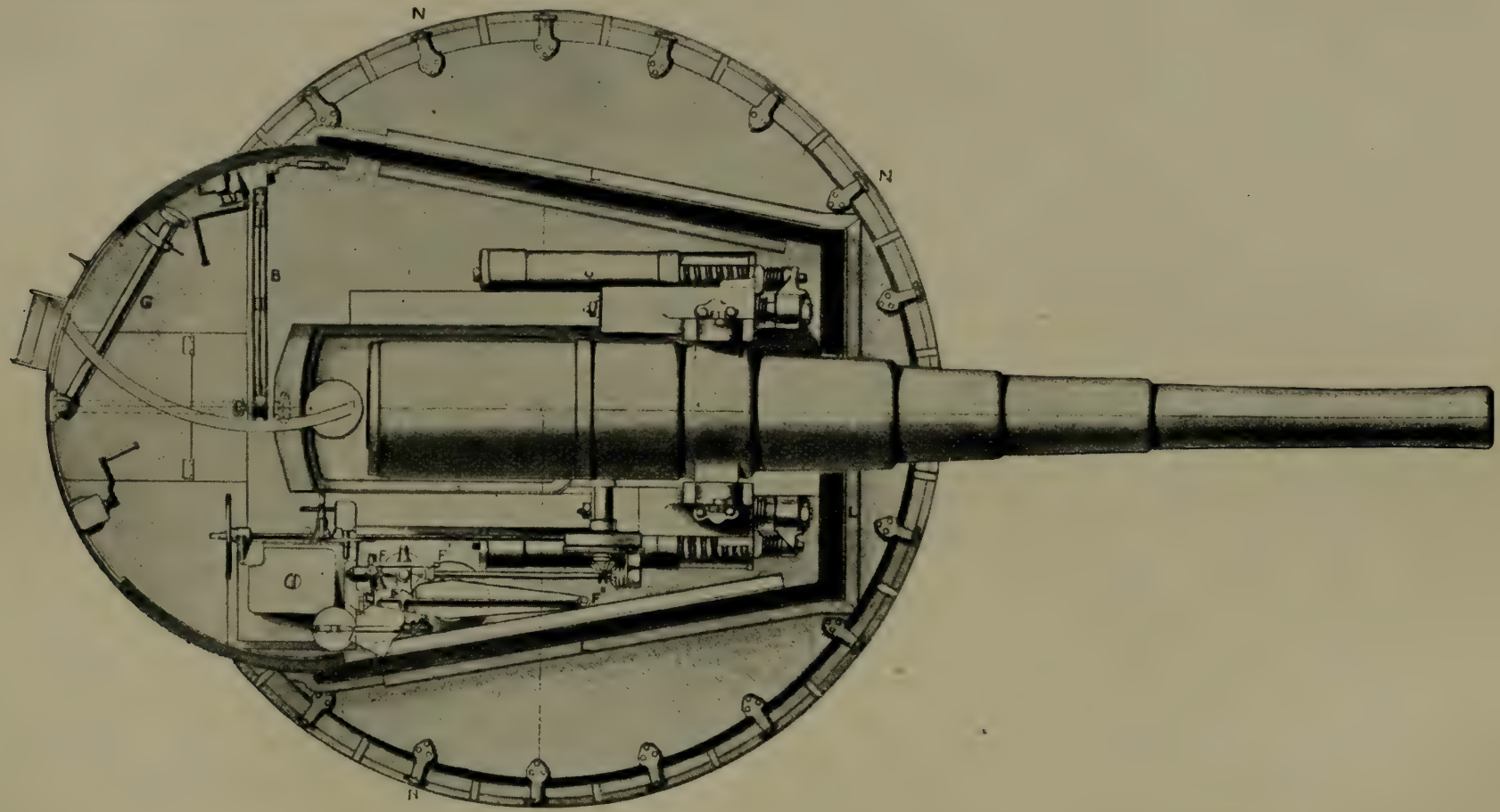
Training is done by a pair of compound engines on the platform deck below the barbette, and an alternative hand training gear is provided, the hand winders gearing to the ordinary spindles.

The recoil of the guns is absorbed by ordinary recoil cylinders and the running out is effected partly by gravity and partly by springs.

In the case of the *Barfleur* arrangements have been made to elevate



9.2-INCH ELSWICK AUTOMATIC MOUNT, WITH PORT PIVOTED GUN. SPECIALLY DESIGNED FOR HIGH ANGLE FIRE.



Plan.

9.2-INCH ELSWICK AUTOMATIC MOUNT, WITH PORT PIVOTED GUN. SPECIALLY DESIGNED FOR HIGH ANGLE FIRE.

Artillery. Its Progress and Present Position.

one of the guns and work the upper ammunition hoists from the shell chamber to the guns by electric motors. On trial the gun was elevated through the entire arc of 42 degrees in 14 seconds, and the ammunition cages were whipped up to the guns in 19 seconds.

Covering each pair of heavy guns at the summit of the barbette armor, which projects through the upper deck, is a nickel-steel pear-shaped shield, consisting of segments laid over a stout steel framework and bolted to it. The thickness in front and round to the sides is 6 inches, but the slope of the armor is so acute that the effective diagonal thickness is over 12 inches. The plates taper to 4 inches at the rear. In the original design for these shields the rear was closed in, but a portion was subsequently cut away in order to reduce the weight of the mount. As, however, the total weight of barbette, turntable, guns, mount, and machinery has been kept down to 210 tons, it is said to be the intention to close the rear with a steel screen, weighing about 4 tons.

The British Admiralty have decided that the 6-inch R. F. G. shall hereafter form the principal armament of all the first-class cruisers and the secondary batteries of the first-class battle ships. Various other powers have followed this example, and have adopted a rapid-fire gun of about the same caliber for similar vessels.

According to London *Engineering*, a rate of 10 rounds in 1 minute and 25 seconds was recently attained at sea from a 6-inch R. F. G. on an Elswick mount.

An 8-inch R. F. G. has recently been introduced by Sir William Armstrong's firm, which is said to have been worked and fired by a crew of 5 men at a rate of 3 rounds in 30 seconds, i. e , 15 seconds interval between rounds, while the corresponding interval with the service 8-inch gun is about 1 minute, 15 seconds.

THE ELSWICK 8-INCH R. F. G.

The gun is of steel and consists of hoops shrunk on an inner tube. There are two keyways, one on the top and the other on the bottom, to guide it in the cradle. The breech hoop carries the attachments for the running-out spring on the top, and for the recoil press piston rod on the bottom.

The length of the gun is 40 calibers, and the chamber is 36 inches long and 8.5 inches in diameter. The rifling is of the usual Elswick pattern, and increases from breech to muzzle, the final twist being 1 turn in 33 calibers.

The breech mechanism is specially designed for rapid loading, but cartridge cases are not employed, and the obturation is performed by a modified de Bange pad.

The breech screw is "coned," being made in two diameters, with the largest diameter in rear, and the front portion is tapered.

Owing to its form the breech plug may swing out directly the threads

are disengaged, thus dispensing with the withdrawal movement required with cylindrical plugs. The action is slightly modified, however, in this gun, as in order to withdraw the de Bange pad from its seat, it is necessary to move the screw a trifle directly to the rear. The motion is combined with that of swinging out in such manner that it appears as one motion.

The screw threads are interrupted in five places, and the interruptions on the rear portion are checkwise with those on the front or tapered portion. The breech screw, therefore, engages with the gun throughout its entire circumference.

The breech plug is born on a gun metal carrier, and a block sliding in the carrier carries a pin which engages in the rear face of the breech plug, and operates in such a manner that if the block is moved laterally it revolves the breech plug. A link attached to a small arm carried by a worm-wheel, which revolves on the carrier axis pin, is the means used to give lateral motion to the sliding block. The worm, gearing into the worm-wheel, is carried by a shaft fitted with a hand wheel.

The shaft is on the right of the gun, and the handwheel is at a convenient distance in front of the breech screw.

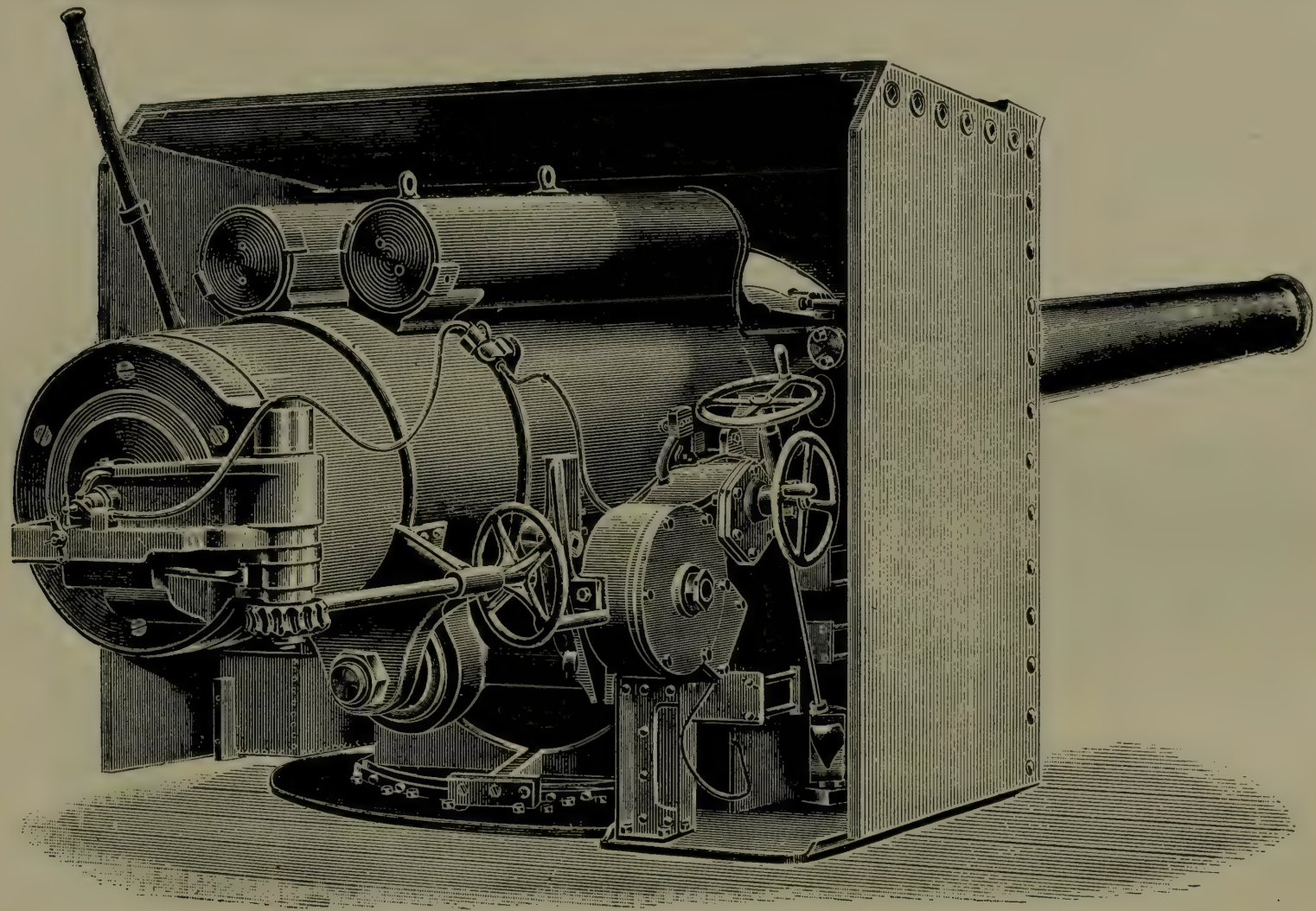
The man who opens the breech is entirely clear of the men who are engaged in loading the gun, and is in such a safe position when the gun fires that even if holding the hand wheel the recoil will not injure him.

Ten continuous turns of the handwheel are required to open the breech, and this can readily be done in 3.5 seconds. The reverse motions for closing the breech occupy an equally short interval of time.

Missfires sometimes occur with large guns when the primer is at the rear end of the breech plug and the vent is very long. To obviate this the primer is attached to a "primer holder," and is inserted about a foot into the breech plug, leaving only about 10 inches of vent between the primer and the charge.

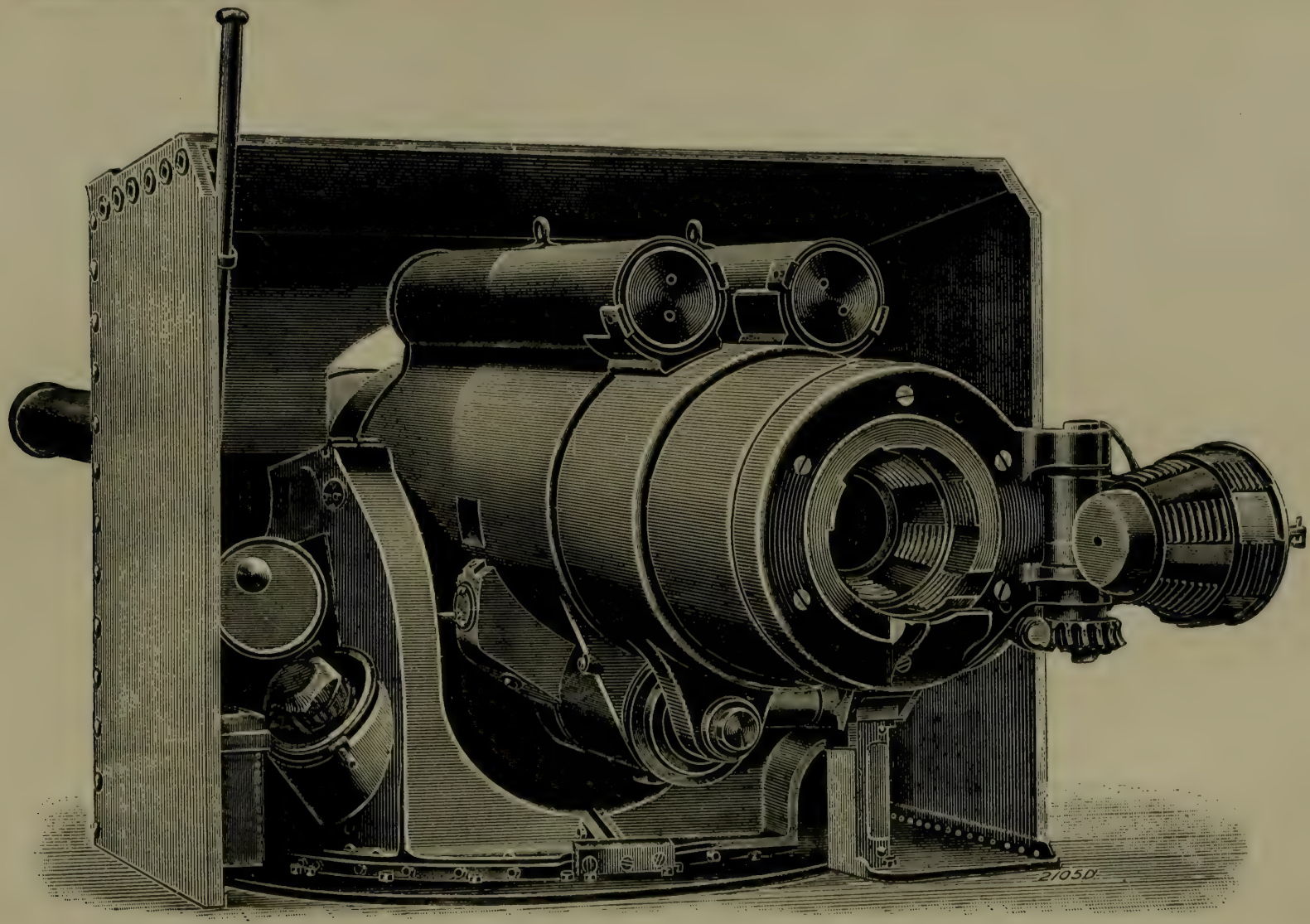
The "primer holder" provides for either percussion or electric firing and is so arranged that it can be easily inserted or withdrawn, and the gun can not be fired unless the primer holder is properly placed. It consists of a steel needle inclosed by a tube of insulating material; outside of this is a steel tube, which in turn is surrounded by a strong spiral spring, which either keeps the striker in contact with the electric tube or serves to drive it against the percussion tube. The entire arrangement is contained in a steel case fitted in front with a short quick-motion screw, on which the cap containing the primer, either percussion or electric, is screwed, and is centered immediately in front of the striker. The striker can not be brought in contact with the primer during the operation of putting the latter in place, as the primer holder can not be withdrawn from the gun unless the striker is drawn back and locked well clear of the primer.

Attached to the carrier is a trigger which may be put in gear for per-



8-INCH ELSWICK R. F. GUN; BREECH CLOSED.

Engineering.



8-INCH ELSWICK R. F. GUN; BREECH OPEN.

Engineering.

ARRANGEMENT OF SIGHTING GEAR (BAR AND DRUM PATTERN.)

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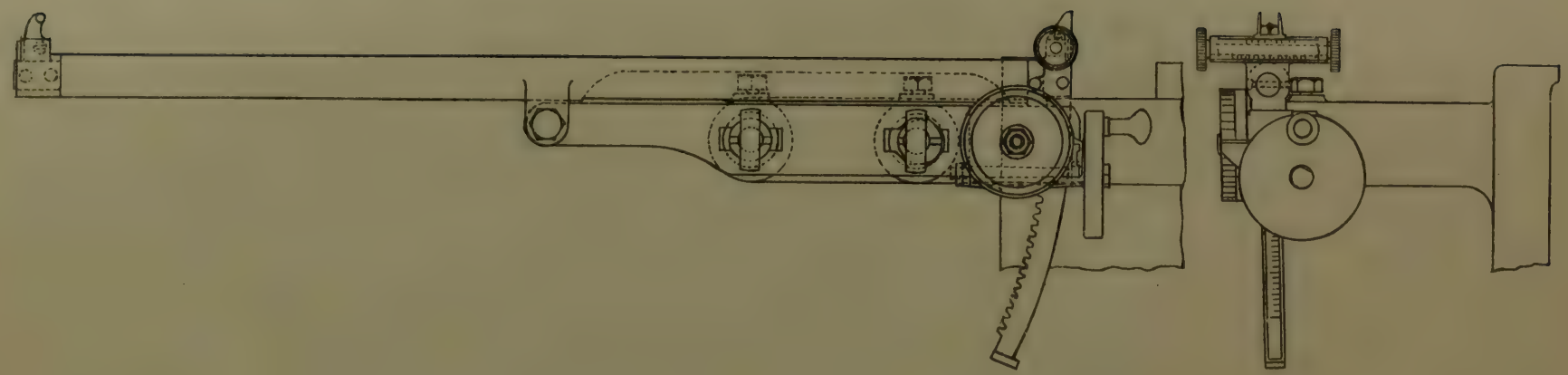


cussion firing or thrown out of gear when electric firing is used. If in the former position it is only necessary to draw the primer holder to the rear to enable it to engage with the trigger, or if the gun is being loaded the opening and closing of the breech performs this automatically. A lanyard may be attached to the trigger and worked from either the right or left of the gun.

The cradle is made of steel, bushed with gun metal where it comes in contact with the gun. There are trunnions on the line about which the loaded gun and cradle balance, and special antifriction gear is used to reduce the friction caused by elevating, so that the gun can be easily elevated or depressed by one man.

The recoil press is underneath the cradle, the cylinder being bored out of a solid steel forging. A tank in communication with the cylinder contains a reserve supply of oil, so that there may be no risk of the cylinder becoming partially empty. Two running-out springs are placed on top of the cradle, each in sections, so that in case of injury a spare section can readily be inserted. The springs are in light steel cases, and can be removed from the mount in their compressed condition without difficulty. A bracket projects from the right side of the cradle, to which is fitted the sight, which is on the "Elswick Bar and Drum pattern."

The two side brackets which support the trunnions of the cradle are bolted in front to an inner shield of 3 inches thickness, and are also riveted to a steel platform which forms the upper roller path. On the right side there are brackets for the elevating and training hand wheels, which are conveniently placed for a man aligning the sights.

While the convenience of sighting with the right eye has not been neglected, some important advantages have been gained by placing the firer on the right-hand side of the gun. The powder hoist is made to deliver the charge on the left side of the gun, and it can be served to the loader without being passed round the breech screw, which, when open, is on the right of the gun. This would be impracticable if the man who trains, elevates, and fires the gun were placed in the usual position on the left side.

The training gear of this mount can be worked at a satisfactory speed by one man, while keeping his eye and attention on the sights, although the revolving weight amounts to 31 tons.

The pistol for firing the gun by electricity is close to the elevating and training wheels. It is fitted with an electric sounder, so that each primer is automatically tested, and the firer is kept informed of the condition of the firing circuit. Another advantage of placing the firing position on the right side is that the circuit is entirely on the same side of the gun as the hinge for the breech-screw carrier, and a short and simple circuit can therefore be arranged.

The mount works on a ring of live rollers, protected from hostile fire by being placed at a lower level than the deck and surrounded by

a plate. Clips attached to the upper roller path and hooked under the lower roller path prevent the front of the mount from rising when the gun is fired.

There are two shields, an outer and an inner, each having a front thickness of 3 inches. The inner shield is an integral part of the lower carriage. The outer shield has an inclined roof 3 inches thick, in which a small port is cut for the gun, and an aperture is provided for sighting. The sides of the shield taper to the rear, and the whole shield is so arranged that it balances about the axis of rotation of gun and mount. Special elastic attachments fasten the shield to the lower carriage, so that considerable distortion may be suffered without injury to the mount.

Central loading is provided for in the case of the powder charge, but the shot are taken from racks placed close at hand.

The powder hoist is capable of very rapid working. Two cages travel in it in such a manner that as one ascends the other descends. The only weight lifted, therefore, is the weight of the charge (of cordite, being 32 pounds). By a simple shunting contrivance the cages pass each other in the middle of the hoist, and there is only one delivery orifice to the hoist for the two cages, this being on the left-hand side of the mount. The cages can be hoisted by a quick-working hand winch whatever the position of the mount.

A door is formed at the bottom of the hoist which can be inclined for supporting the cages when the charges are inserted. Although the cages incline at the bottom of the tube for receiving the charge, and at the top for delivering it, they are securely locked in a vertical position at all other times.

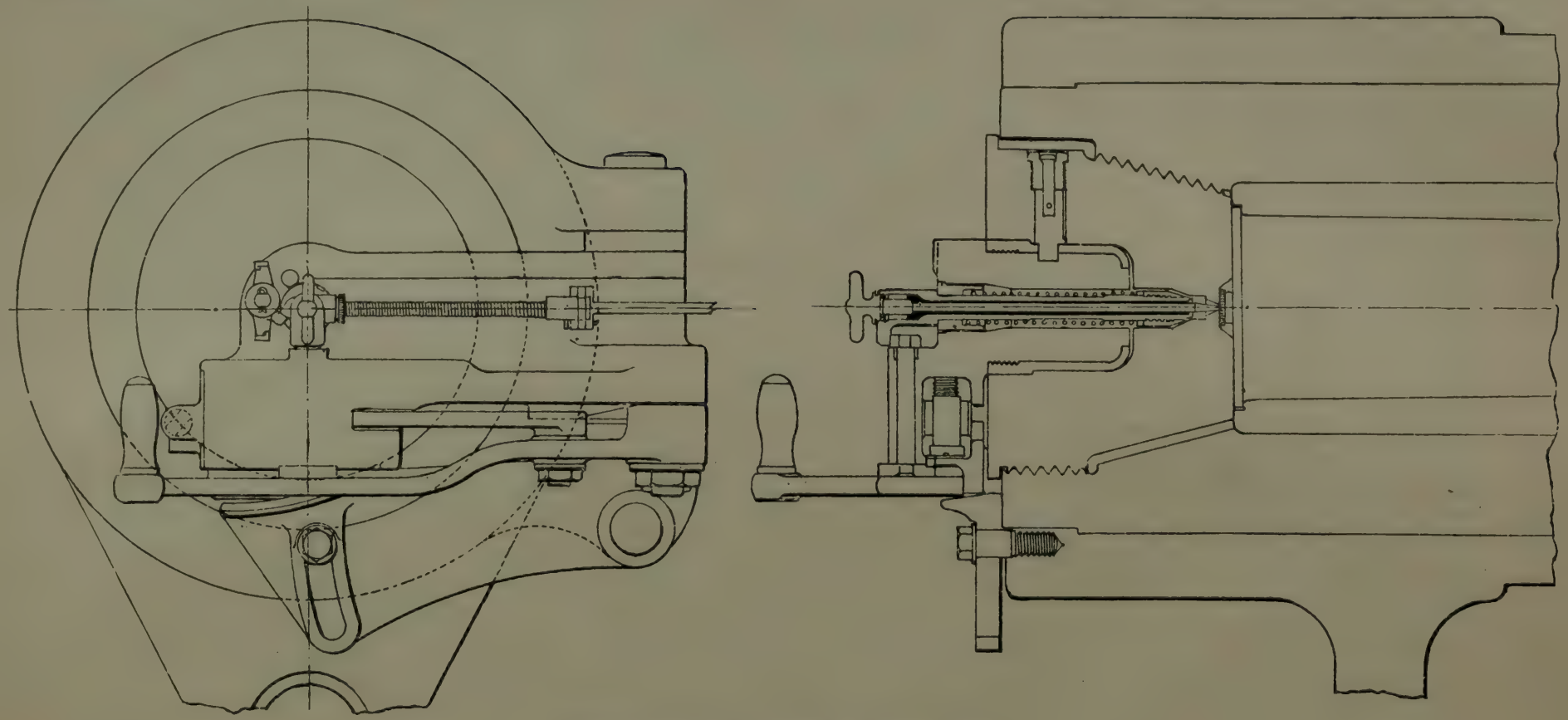
The hoist is well protected by armor plates which are arranged so that certain plates can be removed in case the hoists require examination.

The cages do not travel in close tubes but in frames which are well clear of the armor plates.

Before loading, the projectile is placed in a tray provided with handles, which can be conveniently lifted by two men. The tray serves to protect the breech-screw threads and guides the shot into the gun.

A separate motion for sponging is rendered unnecessary by combining the sponge and rammer, but the sponging is made very efficient by a sponge head provided with alternate rings of wool and bristles. The function of the former is to contain water, while the latter are secured at an angle so as to offer no resistance when the shot is being rammed, but which endeavor to stand up as the rammer is withdrawn, compress the saturated wool and effectually sponge out the chamber.

Although the electric firing system has many advantages, it is customary, at Elswick, to make such arrangements that percussion firing can be resorted to if necessary, and the transfer from one system to the other can be rapidly made.



ELSWICK BREECH CLOSING AND FIRING GEAR.

When percussion primers are used, loading can not be carried out with quite such celerity, as the cartridges must be handled more carefully.

The Elswick firing gear arrangement is as follows: A striker having an insulated pin is carried in the axis of the breech plug, and is pressed forward by means of a strong helical spring. A steel link gears with the breech-screw cam lever and with the striker in such a manner that if the lever is raised the striker is withdrawn and the spring compressed, it is therefore impossible for the insulated pin to make contact with the primer unless the lever is *down*, and as the latter can only be put down when the breech is closed and locked, the gun can not be fired except under those conditions; thus safety against firing without securing the breech is provided for.

On one side of the striker and fitted to the carrier is a trigger arranged so that it can be quickly put in gear for percussion firing or out of gear for electric firing. If in gear it engages and retains the striker when the latter is withdrawn by raising the cam lever; as soon as the lever is down again the link is clear and all is free for the striker to fly forward under the action of the strong helical spring directly the trigger is pulled.

The insulated electric wire is led from the running in and out contact through a tube and nut in rear of the striker; the copper core is then spread out and a perfect contact made by jamming it between the nut, which is insulated, and the head of the insulated pin.

Should a missfire occur, or should the electric sounder fail to ring when the gun is in the "ready" position, the spare circuit can be instantly connected by pushing a split pin, secured to the end of the wire, into a hole in the head of the striker; this will put the spare circuit in connection with the insulated pin and cut out the ordinary circuit and battery. When the spare circuit is used it is necessary to fire with the McEvoy key.

THE ELSWICK SYSTEM OF BREECH MECHANISM.

The breech screw is on the principle of the interrupted screw, but the forward portion is tapered, the rear portion being cylindrical. Two advantages are claimed for this arrangement: Firstly, the working of the breech mechanism is greatly facilitated, as the withdrawal and bringing away of the breech plug can be done in one motion; and secondly, the coned shape enables the screw to distribute the engagement over a much greater portion of the transverse section of the gun. The breech screw is further arranged so that the threads of the coned portion correspond longitudinally with the plain spaces of the cylindrical portion and *vice versa*, thus the strain is distributed thoughout the entire circumference of the breech screw.

The breech plug passes on to the central projection of the carrier from the front and is prevented from coming off by a bolt, which screws

into the breech plug and has a plain end fitting into a groove in the carrier, having the same pitch as the threads of the breech screw, and is of sufficient length to allow the bolt to be turned for screwing up the breech.

The gear is operated by means of a hand lever, on the lower side of the breech plug, which works in a horizontal plane. It pivots on the carrier, and is attached by a connecting rod to a sliding block. A pin in the breech plug works in a vertical slot in the sliding block, so that a horizontal motion of the latter causes the screw to turn. The centers about which the gearing works are on their dead points when the screw is closed, and it is therefore perfectly locked. When the lever is swung round it first unscrews and then brings away the breech plug, the two motions being combined so as to give the operator but one.

The extraction in the larger rapid-fire guns is arranged to take place in two motions. The cartridge cases are started by a powerful extractor, which has only sufficient motion to insure their being free for the remainder of the extraction, the conical shape of the chamber rendering a small amount sufficient for this purpose. The cases are then withdrawn and placed on deck by means of a hand extractor, which fits over and firmly holds the primer.

The mechanical extractor is worked by the carrier in opening the breech closure. It consists of a rod passing through one side of the gun and fitting into the groove for the rim of the cartridge case, in such manner that when turned about its own axis, the fitted part acts as a lever and forces the cartridge case to the rear. A strong helical spring serves to return the extractor to place as the breech is closed.

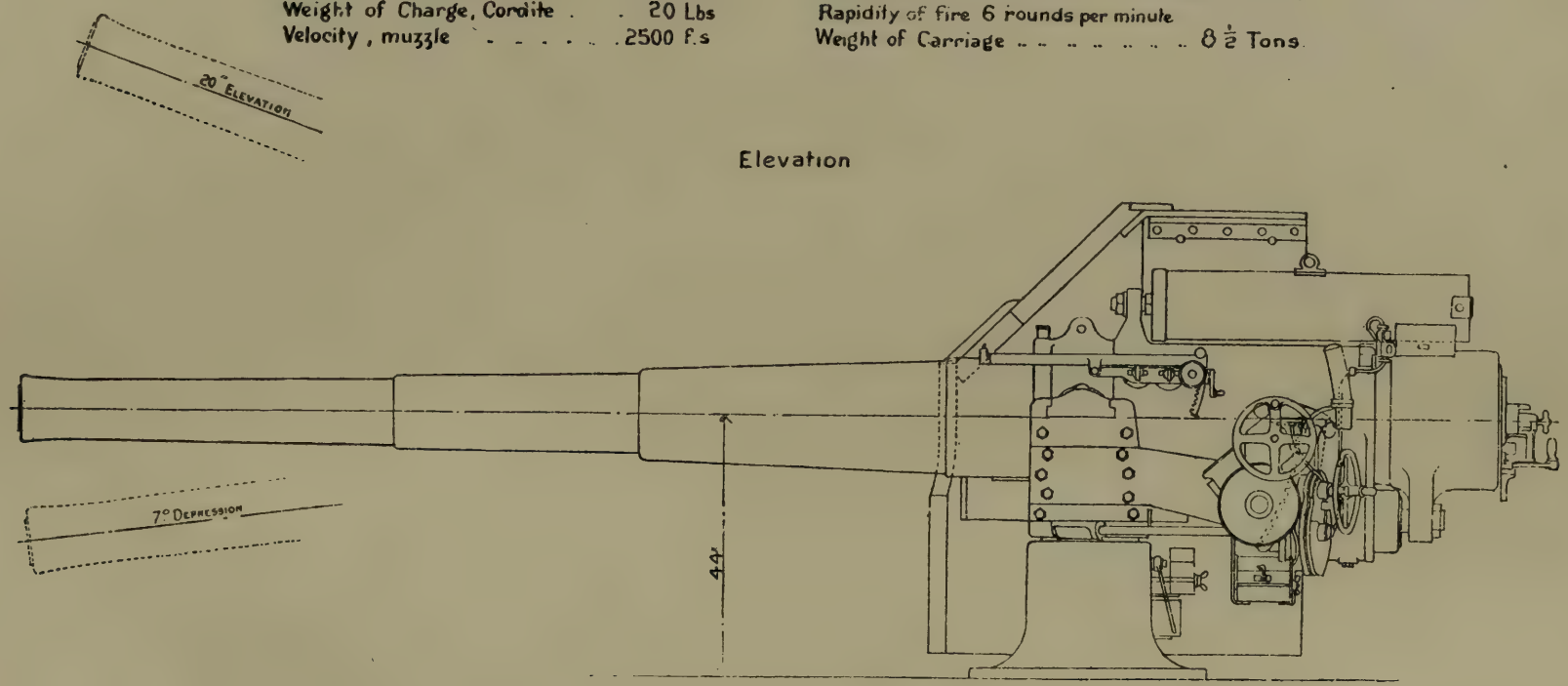
RAPID-FIRE MOUNTS.

The mount for a rapid-fire gun is hardly second in importance to the gun itself, as quick loading and firing would be of little value without special facilities for training, elevating, and sighting.

In the modern mounts the guns recoil in the line of fire, which avoids any sudden blows on the mounts or the deck, such as occur with mounts which, depending on the action of gravity to run the gun out, are arranged so that the guns recoil up inclined sides. The sights generally form part of the cradles in these mounts, and, as they do not recoil, the firer can aim without being disturbed by either the loading or firing.

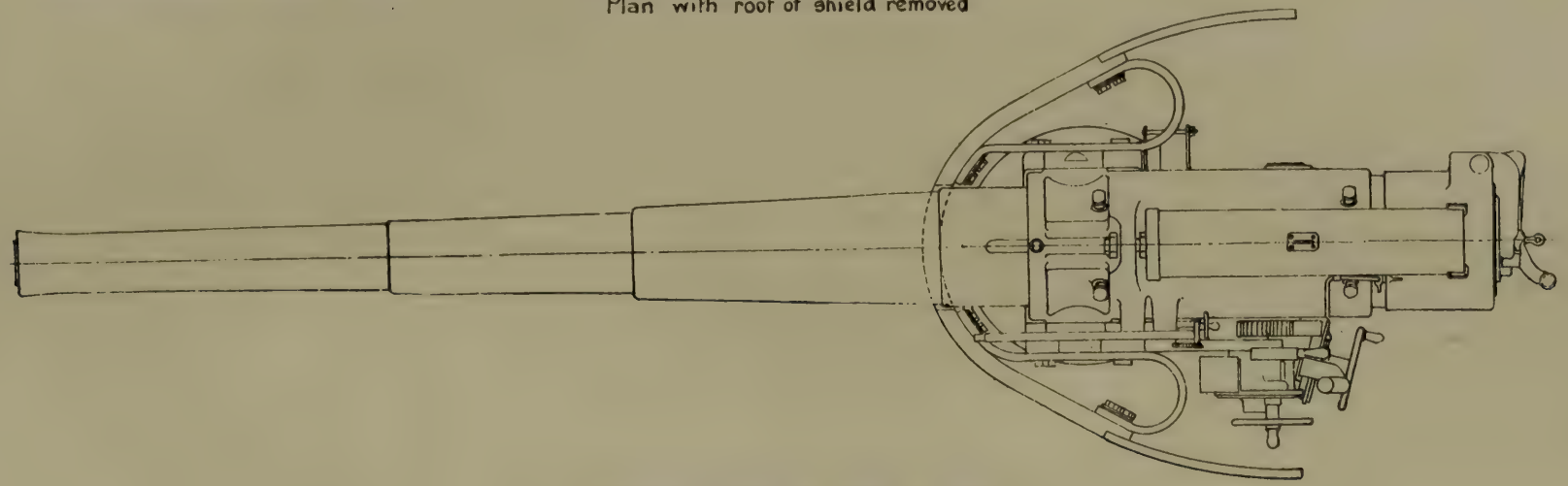
The Admiralty have introduced a new mount for 4-inch, 4.7-inch, and 6-inch R. F. G., which was designed at Sir William Armstrong's Works, Elswick, and is known as the Mark III pedestal mount. It is worked from a pedestal, inside and at the bottom of which is a brass cup containing ten 1-inch steel balls on which the gun and mount revolve. Hitherto the guns have been dependent for their training on 18 rollers worked on a roller path, but owing to their liability to be temporarily disabled by some foreign substance this method of training was not altogether satisfactory. As the ball bearings of the new mount are

Length of Gun	249·25 Inches	Bursting charge of common shell	4 Lbs 12 Ozs
Weight of Gun	6½ Tons	do do steel shell	4 Lbs 7 Ozs
Weight of Projectile	100 Lbs	Shrapnel	800 Bullets.
Weight of Charge, Cordite	20 Lbs	Rapidity of fire 6 rounds per minute	
Velocity, muzzle	2500 f.s	Weight of Carriage	8½ Tons.

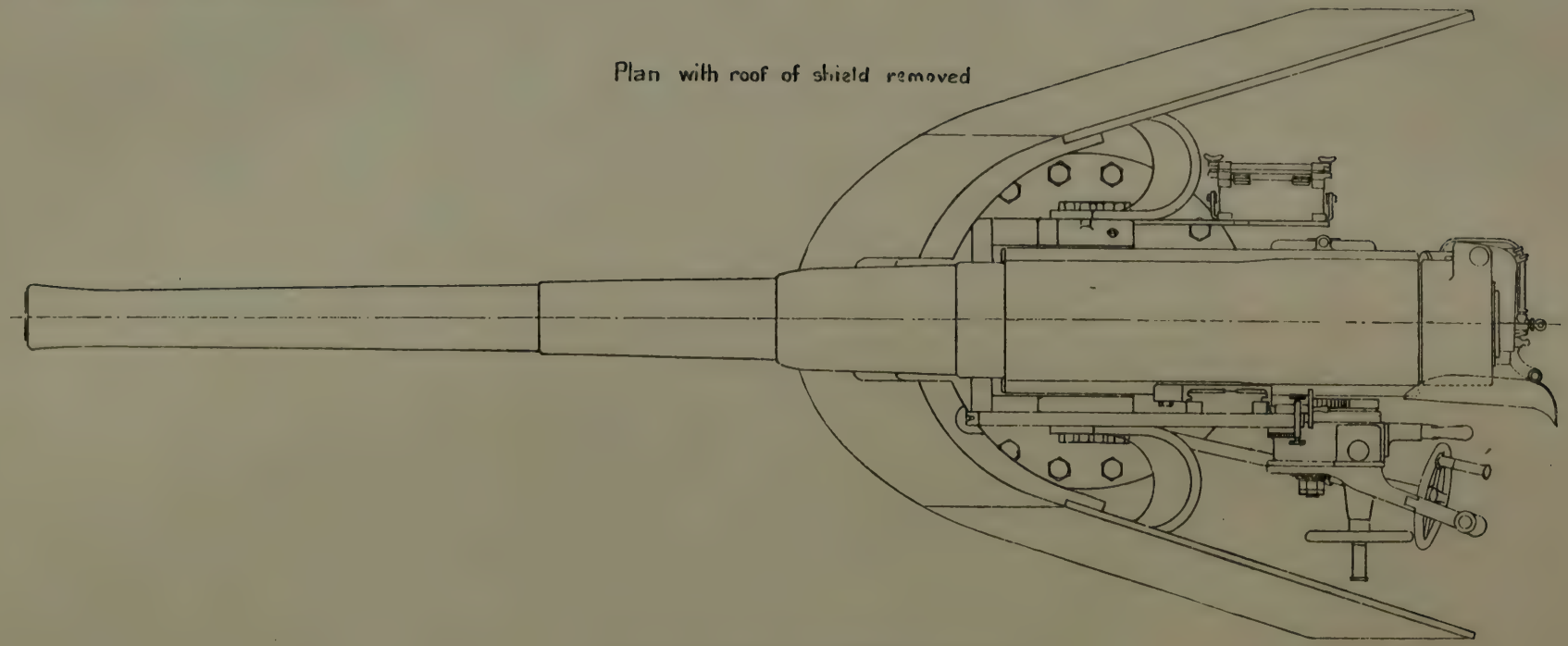


6-INCH R. F. GUN ON PEDESTAL MOUNT.

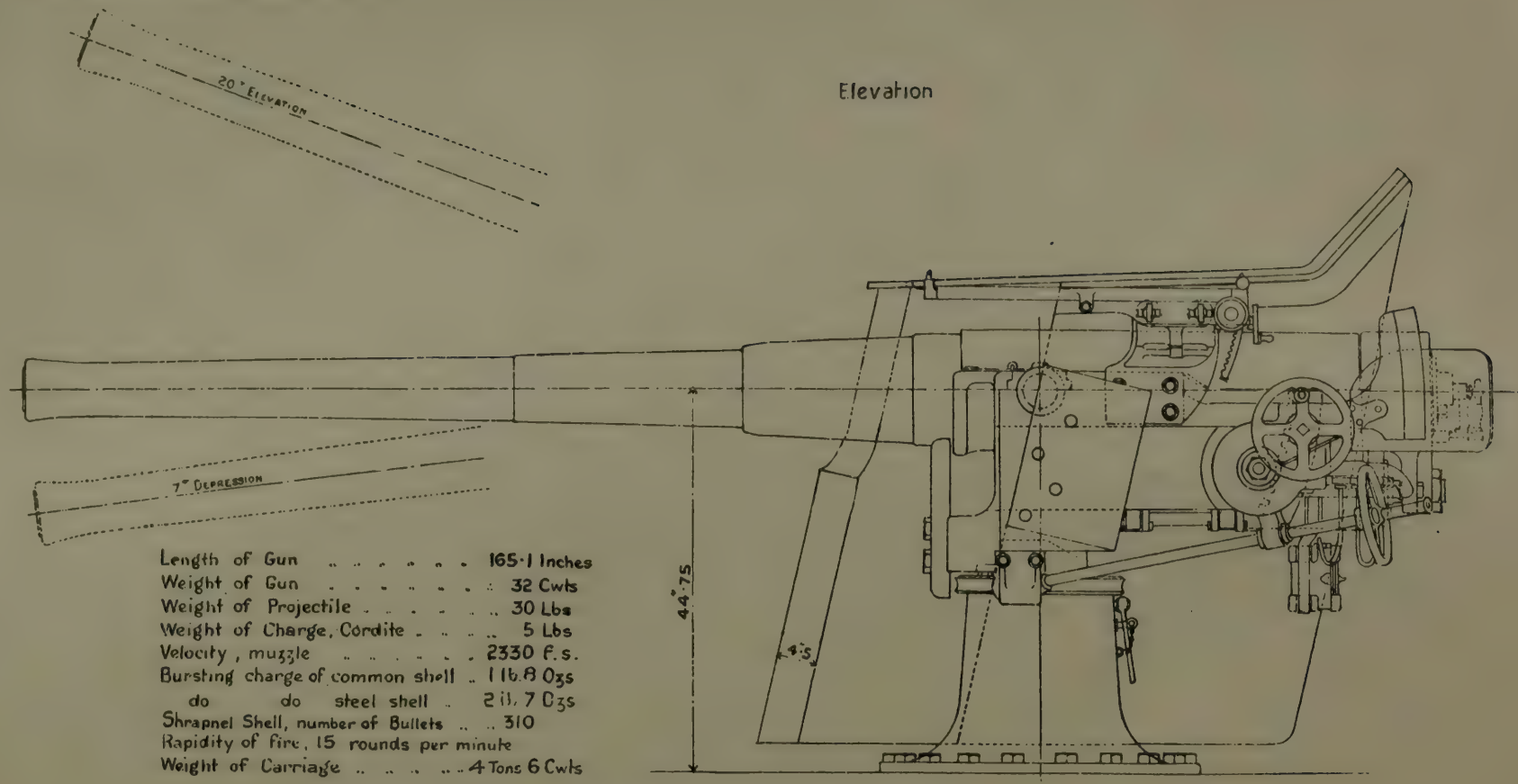
Plan with roof of shield removed



6-INCH R. F. GUN ON PEDESTAL MOUNT.



4-INCH R. F. GUN ON PEDESTAL MOUNT.



Length of Gun	165·1 Inches
Weight of Gun	32 Cwts
Weight of Projectile	30 Lbs
Weight of Charge, Cordite	5 Lbs
Velocity, muzzle	2330 F.s.
Bursting charge of common shell	1 lb. 8 Ozs
do do steel shell	2 lb. 7 Ozs
Shrapnel Shell, number of Bullets	310
Rapidity of fire, 15 rounds per minute	
Weight of Carriage	4 Tons 6 Cwts

4-INCH R. F. GUN ON PEDESTAL MOUNT.

inclosed in the pedestal it is impossible for them to be affected by any outside agency. One great advantage of the pedestal mount is that as the heavy rollers and roller path can now be dispensed with, their equivalent in weight can be utilized by strengthening the shield which protects the gun's crew. The new shields will also be fitted with a sliding roof 3 inches thick. The roof and front of the shields will then be able to resist projectiles fired from 6-pounder rapid-firing guns at a distance of 700 yards and from 3-pounder rapid-firing guns at a distance of 100 yards, whilst the fire from machine guns is rendered practically useless even if the thinnest parts of the shield are struck.

The new mounts are to be installed on board all new vessels which have not yet received their armament.

A cradle of the usual form carries the gun, and the trunnions of the cradle fit into a forged steel shaft, or pivot, with a fork at the upper end. The lower end of the pivot rests on a bearing secured to the base plate of the pedestal, which incloses the pivot shaft and also forms a bearing for it just underneath the fork. The shock of firing is transmitted from the fork to the pedestal, while the friction caused by training only acts on the small area of the base of the pivot and is reduced to a minimum by the steel balls.

The mounts are designed to train by a shoulder piece if desired, a friction clamp connecting or disconnecting worm gearing as required.

Elevation is given by a handwheel, which gears with the shafting into the elevating arc on the cradle, and is placed conveniently for use with the left hand, while the right eye is kept on the sights, the right hand on the firing pistol, and the left shoulder at the shoulder piece.

This arrangement enables one man to train, elevate, and fire without moving his eye from the sights. With heavy guns, which can not be readily trained with a shoulder piece, the right hand may be used for this purpose, and then changed to the firing pistol to fire. An arrangement has been devised by which such guns can be electrically fired by the knee, thus rendering it unnecessary to remove the right hand from the training wheel.

In the 4-inch mount the running-out springs are placed underneath the cradle, where they are less liable to injury, and special efforts have been made to provide a clear field of vision for the firer by placing the line of sight above the roof of the shield, the man's head being protected by a sloping shield.

In the other mounts, however, the recoil press is below, but the running-out spring is above. Later designs will have the running-out spring underneath also.

The sighting arrangements are on the "Bar-and-Drum" principle.

In the British navy a sight known as the H sight, which was invented by Lieuts. Arbuthnot and Foote, R. N., has been introduced, and is received with great favor. The sight consists of a wire stretched horizontally between two uprights, thus resembling the letter H. It is

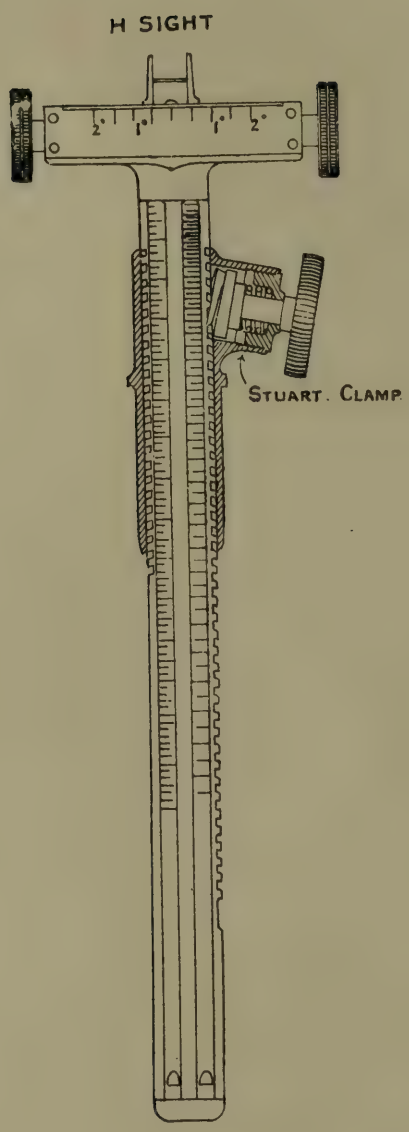
claimed that this sight possesses peculiar advantages under the conditions obtaining at sea. A ship is a moving platform and the moment for firing has to be chosen when the motion brings the sight on the object. The power of keeping the object in the field before this occurs conduces very much to accuracy, and it can readily be obtained by sights of the form shown.

As changes in the muzzle velocity due to alterations in the charge or the weight of projectile are always to be anticipated, modifications in the graduations for range may be necessary. The graduations are, therefore, made on strips of aluminium, which are fitted to slide into grooves cut in the sight bars, and the sights can, therefore, be regraduated without altering the more costly portions of the apparatus. Provision is made for moving the head of the rear sight so that the sighting line may be inclined to the line of fire and allowance thereby made for the effect of the wind, the speed of a moving object, or for the speed of the vessel from which the gun is to be fired.

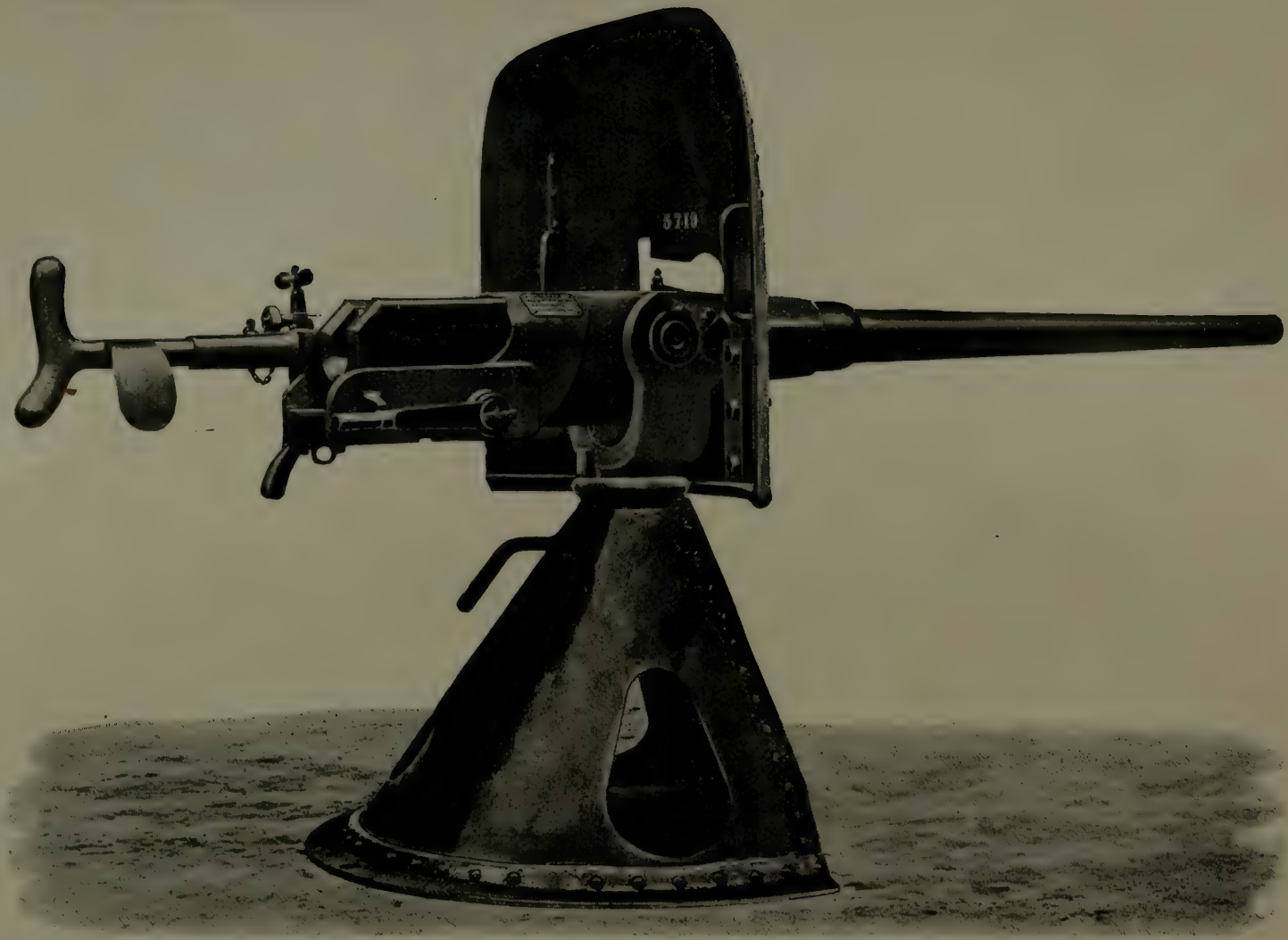
A graduated scale is provided to guide the movement of the head of the sight, and is controlled by a hand screw. As any accidental movement of the sight after it has been adjusted may cause the loss of a shot, it is important to have some means for accurately and quickly adjusting the sight bar, and an excellent arrangement for this purpose is known as "Stuart's clamp." This consists of a small socket, containing a handwheel, which carries a shaft, and can be turned in either direction, or may be withdrawn toward the rear in opposition to a spring. The turning movements raise or lower the sight slowly, but accurately, while the withdrawing movement liberates the sight bar so that it can be rapidly raised or lowered by hand to any approximate position. The clamp, owing to its special worm and rack, also holds the sight bar without any risk of movement by the jar of firing.

All rapid-fire guns mounted between decks on board naval vessels are to be fitted with arrangements to enable them to be run in and housed. Under ordinary conditions at sea they are to be stowed entirely inboard, and only run out when required for exercise. Experiment has demonstrated that the 6-inch gun, weighing, with its cradle, over 8 tons, can be housed in four minutes, and can be replaced in position in even less time.

The admiralty have ordered that the old muzzle-loading and obsolete breech-loading guns stored in various parts of the world for the armaments of merchant steamers converted into cruisers in time of war shall be replaced by breech-loading and rapid-fire guns of the latest patterns. Twenty-six sets of armanents have been ordered distributed as follows: At Devonport, 8; at Woolwich, 8; at Portsmouth, 4; at Hongkong, 4; and at Sydney, 2. Thirteen of these sets consist of eight 4.7-inch R. F. G. and eight 4-barrel 1-inch Nordenfelt guns, and the other thirteen of eight 5-inch B. L. R., and eight 4-barrel 1-inch Nordenfelt guns. There are to be over fifty sets of such armaments distributed in all.



Artillery. Its Progress and Present Position.



MAXIM-NORDENFELT AUTOMATIC 6-POUNDER R. F. GUN.

Maxim Nordenfelt Company's Catalogue.

THE MAXIM-NORDENFELT AUTOMATIC 6-POUNDER R. F. G.

The principle exemplified in this gun may be considered as a new departure. The gun does not differ materially in construction from the other 6-pounder guns, except that it is without trunnions. It fits into a gun-metal cradle in which it recoils, and the portion of the gun which works in the cradle is made cylindrical. The cradle is fitted with trunnions which rest in the trunnion bearings of the mount. Two combined hydraulic and spring buffers are attached underneath the cradle, and to the piston rods to which the gun is connected. In the rear of the cradle is a pistol grip which contains the trigger, and on the right side is a detachable lever by the movement of which the breech block can be lowered or raised. The breech block is capable of vertical movement and contains the main spring, firing pin, etc. Situated between the buffers, underneath the cradle, is a powerful flat spring, the action of which works the breech block.

To prepare the gun to commence firing, the breech is opened by the movement of the hand lever, which turns a crank the action of which brings down the breechblock and compresses the flat spring situated between the buffers. At the same time the mainspring is compressed and is kept in this condition by the action of the sear and safety gear. The breechblock in moving down strikes the lower extension of the extractor and causes the upper portion to move out from the face of the end of the barrel, and brings down two small projections over the upper edge of the breechblock and thus prevents it from rising by the reaction of the spring. The cartridge is pushed into the bore, and going forward to its seat the rim strikes against the extractor and forces back the projections which prevented the breech from rising; the flat spring acts and rotates the crank, thus raising the breech-block, the last upward movement of which disengages the safety sear, so that, when the trigger is pulled, the hammer is thrown forward by the action of the mainspring. To commence firing, the trigger is pulled and the gun is fired and recoils in the cradle; the recoil, which is controlled by the hydraulic buffers, compresses the spiral spring round the piston rods, and the reaction of the spring at once returns the gun into its firing position in the cradle.

As the gun returns it acts on the mechanism, which causes the crank to rotate and thereby brings down the breechblock. The extractor is actuated by the fall of the block, and, first loosening the cartridge case by a slow movement, finally ejects it to the rear.

The gun is now in readiness for another round, the cartridge for which being placed in the gun the breech will be closed and secured automatically.

The inventors claim the following advantages for this gun over ordinary R. F. G. of the same caliber:

(1) The operations of opening and closing the breech being per-

formed by the action of the gun during its return from recoil can not be effected prematurely, thus avoiding all risk from "hang-fires."

(2) The hand lever not being used for working the breech mechanism, the man laying the gun can devote his entire attention to this important duty.

(3) One man less is required for the efficient working of this gun than for other R. F. guns.

(4) The line of sight is not disturbed by the action of the hand lever.

Finally, the mechanism is simple and strong, and can be dismounted and assembled without the use of tools. In case of an accident to the mainspring or firing pin, the defective portion can be readily replaced.

THE MAXIM AUTOMATIC 1.46-INCH MACHINE GUN.

The gun consists of a barrel, surrounded by a water jacket, and the requisite mechanism.

The mechanism and the working of the gun are similar to those of the rifle-caliber automatic machine gun. It is entirely automatic in action, being fed with ammunition by means of a belt.

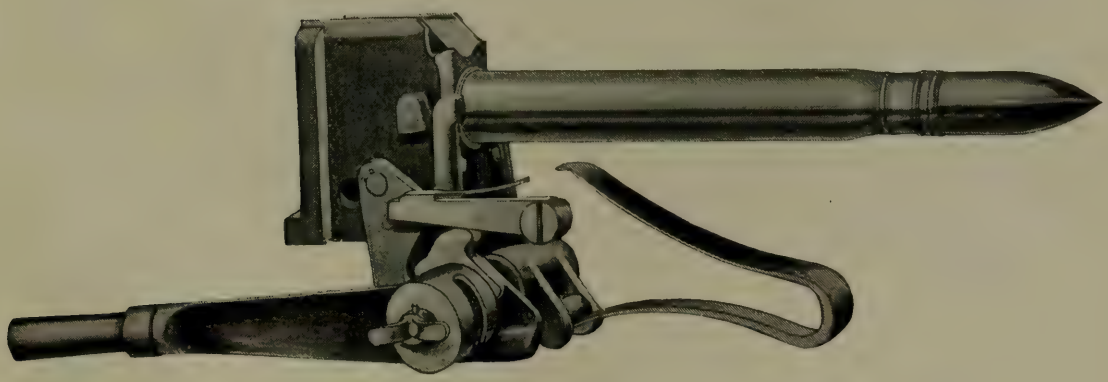
In the illustration the gun is shown on its naval mount. It combines, in a marked degree, simplicity, strength, and nonliability to get out of order. All the parts of the mechanism are strong, and, in case of accident, the faulty mechanism can be readily removed and replaced in a few seconds. As the automatic character of the firing has no tendency to derange the pointing, the accuracy is superior. Only one man is required to work the gun and he can devote his entire attention to pointing it. The ballistics are extremely good and the projectiles excellent.

This gun was designed to meet requirements for increased rapidity of fire, and is expected to be especially useful for defense against torpedo boats with high speed. As it is adapted for the use of smokeless powder, a distinct view of the target may be maintained at all times and the gun pointed with accuracy. Its caliber is large enough for the use of projectiles of sufficient weight to penetrate the sides of lightly-protected boats and carrying a bursting charge, thus increasing the chances of causing damage in the interior of the boats.

The ammunition is placed beforehand in canvas belts and kept ready for use in ammunition boxes supplied for the purpose. In preparing for action the box is placed in position and the end of the belt passed through the feeding attachment, when the gun-firer can begin firing immediately. Belts are supplied to hold 25 or 50 rounds, and ammunition boxes can be supplied of any desired size. The gun is so light that when firing at a rapidly-moving object, it can be trained with the utmost ease. The left shoulder of the gun-firer being firmly pressed against the shoulder piece and his right hand on the pistol grip, he has complete control over the movements of the gun.

The enormous rapidity of fire and the absence of smoke enables the

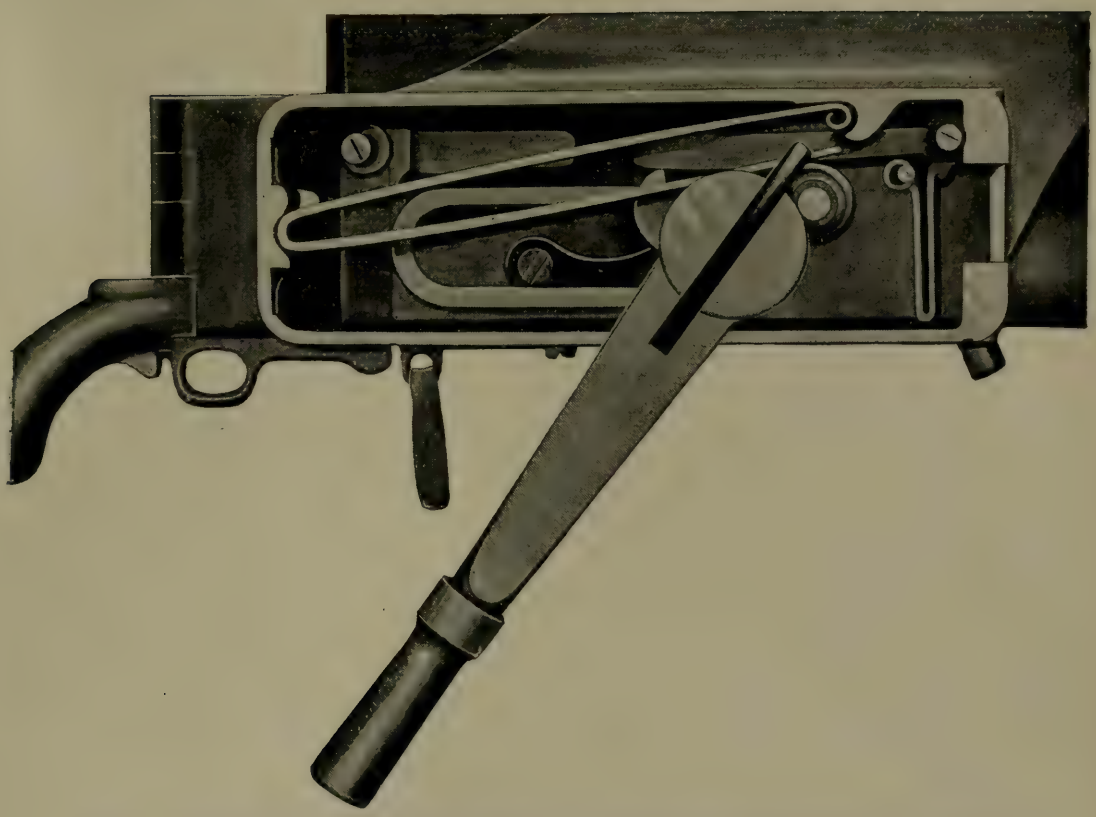
No. 1.—Action spring placed between the buffers; breechblock down and spring compressed.



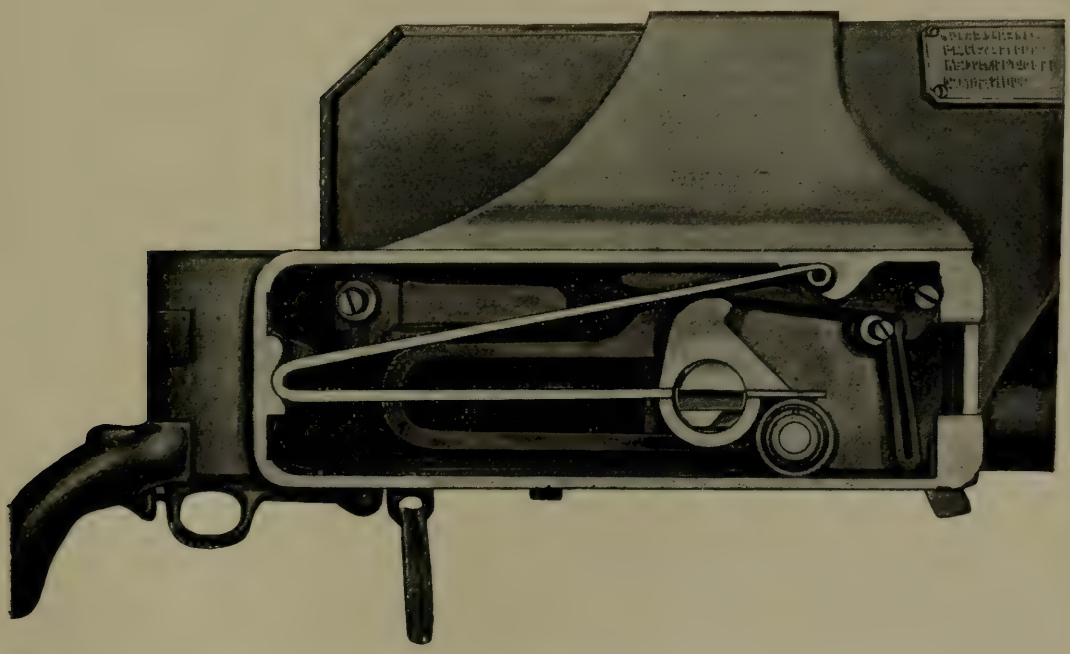
No. 2.—The same as No. 1, but with breechblock up and spring not compressed.

MECHANISM OF THE AUTOMATIC R. F. GUNS.

Maxim Nordenfelt Company's Catalogue.



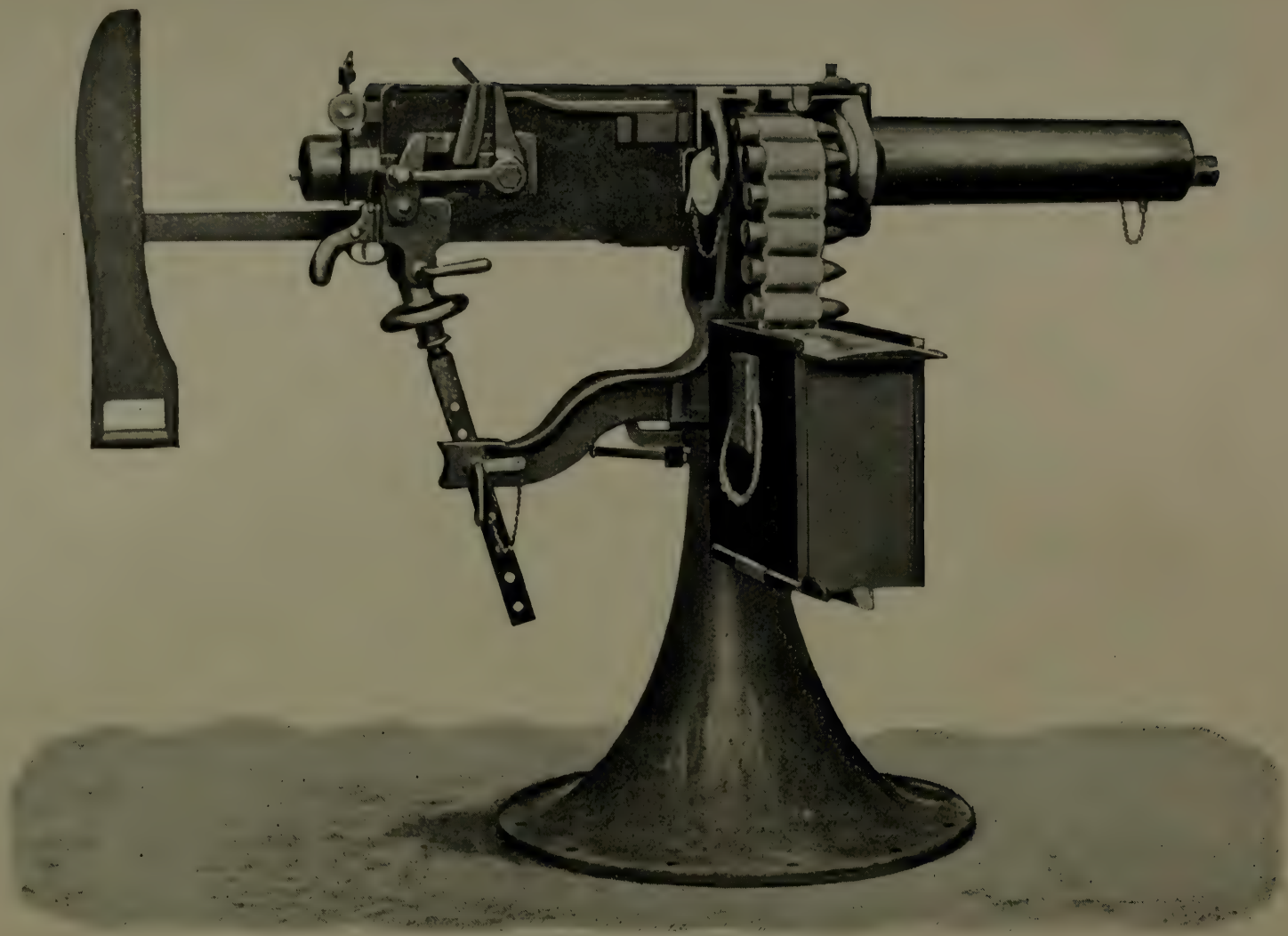
No. 3.—The action spring placed in side box; breechblock down and spring compressed.



No. 4.—Same as No. 3, but with breechblock up and spring not compressed.

MECHANISM OF THE AUTOMATIC R. F. GUNS.

Maxim Nordenfelt Company's Catalogue.



MAXIM AUTOMATIC 1.46 MACHINE GUN.

Maxim Nordenfelt Company's Catalogue.

gun-firer to hit any moving object at long range without even using the sights. As the striking of the projectiles causes a marked disturbance on the water, it is only necessary to bring this point of disturbance directly on to the object in order to completely riddle it with shot.

A magazine containing cartridges may be kept ready attached to the gun, so that it will only require the movement of the handle to start firing and enable a man without any assistance to pour out a steady stream of projectiles in any desired direction. That the great advantages of this gun are fully recognized by most of the naval powers of Europe is shown by the trials which have recently taken place.

In Russia some interesting and conclusive trials were had, and it is said that the gun has been adopted in the naval service.

During some recent experiments it is said that 240 rounds per minute were fired from it repeatedly. The smokeless powder used enabled its full effect to be obtained, and the mechanism gave complete control of the amount and rapidity of fire. Trials are in progress in England and Turkey, whilst tests are about to be made in Germany, Italy, and Spain. After extended trials a substantial order was given for these guns for the French navy, the guns to be made and tried in France.

Particulars of the Maxim 1.46-inch machine gun.

Caliber	inches	1.457
Weight of gun, complete	pounds	420
Length of gun, complete	inches	64
Rifling, uniform	1 turn in 30 calibers	
Weight of—		
Mount, complete	pounds	336
Steel shell	do	1.0675
Common shell	do	1
Complete cartridge	do	1.49
Length of complete cartridge	inches	6.42
Weight of powder charge (smokeless)	1 ounce 60 grains	
Velocity at—		
Muzzle	foot seconds	1,445
1,000 yards	do	801
3,000 yards	do	373
Weight of powder charge (smokeless)	ounces	1.5
Velocity at muzzle	foot seconds	1,800
Perforation of wrought iron at—		
Muzzle	inches	2.25
100 yards	do	2.04
600 yards	do	1.25

FRANCE.

The French navy estimates for 1895 include the following items: Manufacture and repairs of ordnance, 7,000,000 francs ($1,351,000); extraordinary for new ships, 1,000,000 francs ($193,000); supplementary, 700,000 francs ($135,100); ammunition, etc., 13,900,000 francs ($2,682,700); torpedoes, 3,877,000 francs ($740,607). Total, 26,077,000 francs ($5,102,407).

The minister of marine has directed that in future all naval and coast-defense guns are to be designated by their exact calibers in millimeters. Thus, the 27-centimeter gun will hereafter be styled 274.4-millimeter (10.8-inch); the 16-centimeter gun, 164.7-millimeter (6.48-inch), and the 14-centimeter gun, 138.6 millimeter (5.45-inch), as the designation in centimeters does not correspond with the exact caliber of many of the guns.

Many improvements have recently been made at the Naval Gun Factory at Ruelle. New shops have been built, modern tools introduced, and an extensive cartridge-case plant has been installed.

The time required to build a 164.7-millimeter (6.48-inch) gun at this factory is reported to be about eight months, and about eighteen months are required to construct a 300-millimeter (11.81-inch) gun.

The main armament of the new battle ships will consist of 300-millimeter (11.81-inch) guns, 45 calibers long in the bore, and 164.7-millimeters (6.48-inch) R. F. G.

The *Jaureguiberry* is also to have two 300-millimeter guns, L/45, and *Masséna* two 300-millimeter guns 50 calibers long.

The 300-millimeter gun, L/45, weighs, with breechblock, 45.4 tons, and the extreme length is 45.9 feet.

The guns can be trained laterally by hand or by electric motors. The space reserved for manœuvring is sheltered beneath the armored deck above the ammunition stores, but the gun is laid direct from the pointing shelter, where electric switches are placed, connected with the motors under the protective deck. There are two of these motors, of the bipolar Gramme ring type, driven at the same speed and developing equal power. The operations are controlled by a system of two commutators, one of which is placed in the power room and the other in the shelter within reach of the man training the gun. The former follows the movements of the second absolutely, and delivers current to the rings of the motor; the commutators are so arranged that they can can be stopped, reversed, or the speeds varied at will. In order to stop the motors very promptly, a condition necessary in this application, they can be changed into powerful brakes by making them discharge into a suitable resistance a current of considerable intensity. The upper commutator, which serves solely to control the lower one, is operated by a very slight current, and its size is reduced as far as possible, so as not to be inconvenient in the limited space within the shelter. Close to the hand of the operator is a lever that can be moved to the right or the left, and which returns automatically to zero when released. It controls mechanism by which four different speeds can be given to the turret, and which are required, when training the gun, to include large angles; the accurate pointing is completed by manœuvring two contacts, one of which moves the gun to the right and the other to the left, the range of motion being controlled by the length of

time that the button is depressed. With a little practice the range of movement can be regulated to 0.1 degree.

The electric motors are supplied by two distinct circuits, one for the exciting current, the other for the armatures. The former current is always maintained at 70 volts; it is furnished from the lighting dynamos, and remains invariable, whatever may be the speed of rotation. The armatures take a current of 140 volts, or one of 70 volts, the former representing the normal condition of work. With the 70-volt current the speed of the motor is reduced to half. Two special electric installations are devoted to the armament of the ship, independently of the lighting dynamos. They each comprise one horizontal compound engine driving direct two compound dynamos of 500 ampères and 70 volts. These dynamos mounted in series furnish a current of 70 or 140 volts, as may be desired, by means of a special distributor, and in case of either one being damaged it can be cut out of the circuit, one-half the power being sufficient to manœuvre the guns and turrets, though at a reduced speed.

Almost all the vessels in active service now have the R. F. G., and it is expected that within the present year all vessels in commission will be so armed. All of these guns have Canet breech mechanism, operated in one motion, and are mounted on the regular Canet C. P. mounts. The operation of fitting the 138.6-millimeter (5.45-inch) and 164.7-millimeter (6.48-inch) R. F. G., 45 calibers long, assembled and rifled at Ruelle, with the Canet breech mechanism and Canet mounts is completed and most of the guns have been delivered.

The 138.6-millimeter (5.45-inch) R. F. G., model 1891, has a tube 21 feet long, a jacket 6.79 feet long, and a sleeve 4.9 feet long. A collar screws on the rear end of the tube and carries the breechblock. The rear hoop goes on over the collar and jacket, being screwed to the latter. Five short hoops are shrunk on over the jacket, and one conical hoop locks the jacket and sleeve together. The weight is a trifle over 4 tons.

The 164.7-millimeter (6.48-inch) ammunition for R. F. G. has always been in two parts, and it is now determined to separate the projectile from the cartridge in the 138.6-millimeter (5.45-inch) as well.

All R. F. ammunition is loaded with smokeless powder.

LATEST DEVELOPMENTS IN CANET R. F. G.

Taking the types already illustrated and described (p. 102, No. IX) and other publications as standards of comparison, we find that the length of the gun has been considerably increased, the reenforcing rings have been strengthened, and the shape of the bore and chamber have been modified to better adapt them for burning larger charges of smokeless powder. Alterations have also been introduced in the form of the cartridge case, especially in the direction of

increasing the amount of clearance in the chamber, in order to facilitate extraction.

The breech mechanism has been made the object of several modifications. While the interrupted screw block has been retained, the ring and bracket to which it is attached have been made stronger, and the block itself is more accurately guided during its movement of withdrawal and its swinging to the rear. The slide is also more efficiently guided upon the bracket.

The breech is opened by the movement of a single lever acting on the block, the movement taking place from left to right in the latest pattern guns. The form of the groove in which travels the roller of the small arm mounted on the shaft has been modified, and a cam of special form now acts as an abutment to the lever when the rotating movement begins, which greatly facilitates the starting of the cartridge case from the chamber. The extractor claws are pivoted on a bolt in the breechblock, and are formed with a heel, the back of which presses on a coiled spring fitted in a recess in the block. The connection between the ring and the breechblock with the body of the gun is made by means of a bolt with inclined faces, but without a spring.

The charge is fired by percussion, but instead of having, as in the old types, a percussion primer screwed into the cartridge case a primer is now used which is less liable to cause a missfire. This primer is exploded by means of a long striker actuated by a spring and placed within and along the axis of the breechblock. To the rear of the block is a detent which runs upon a vertical axis borne in a projection of the slide, on which is a finger which operates the striker. When the gun firer pulls the detent the striker is liberated and thrown forward with great force against the primer by means of the spring already mentioned.

The gun may be fired from behind by pulling the lanyard, which is passed through the eye at the rear of the detent, or it can be fired while the gunner keeps his eye upon the sights, in which case the lanyard is attached to a small lever on the side of the detent and then passes over a projection on the movable part of the carriage which recoils with the gun. An efficient and simple safety apparatus prevents the detent from turning on its axis and firing the primer before the breech is completely closed.

The passage in which the striker works can be utilized for firing electrically by exchanging the striker for an ebonized bar in which the conductors are contained.

This pattern of breech closure is operated entirely by hand and comprises no automatic device whatever.

The latest types of guns are furnished with automatic sighting devices, which greatly simplify the labor of training; they are also sup-

plied with luminous sights for night firing, which allow the guns to be laid with accuracy.

The combination of all the improvements enumerated has developed a very powerful type of gun, which is at the same time exceedingly simple and very easily handled.

The series of R. F. G. made by M. Canet, apart from a few intended for special service, comprises 21 calibers, ranging upwards from that of 65 millimeters (2.56 inches) to 150 millimeters (5.91 inches). Thirty 10-centimeter (3.94-inch) R. F. G., 55 calibers long, have been delivered by the Forges et Chantiers de la Méditerranée at Havre.

From M. Canet we learn of some extremely interesting experiments which were made some time since at the Hoc Polygon with a Canet gun of 10 centimeters (3.94 inches) and 80 calibers in length. In the first few rounds ordinary brown powder was employed, and a velocity of 826 meters (2,710 feet) was obtained without exceeding normal working pressures in the bore.

Four specimens of smokeless powders of different qualities were employed in the subsequent trials. With them the maximum velocity recorded was 1,026 meters (3,366 feet), the pressure exerted in the gun being 2,980 kilograms per square centimeter (18.91 tons per square inch).

With a slower-burning sample the initial velocity was 1,006 meters (3,301 feet), with a pressure of 2,785 kilograms per square centimeter (17.68 tons per square inch), which is not much in excess of working limits.

In spite of its great length and the severe trials to which the gun was subjected, no sensible deflection was noticed in the bore at the end of the tests. The breech mechanism is the same as that adopted for the Canet R. F. G. supplied to the French navy.

The trials were carried out under the control of a special commission appointed by the minister of marine, and under the presidency of Col. Leherle, director of the Laboratoire Central.

The following table contains the particulars of the results recorded in the experiments referred to and furnishes proof of the rapid progress made by M. Canet in the development of modern guns.

Firing trials of a 10-centimeter (3.94-inch) Canet R. F. G., 80 calibers long.

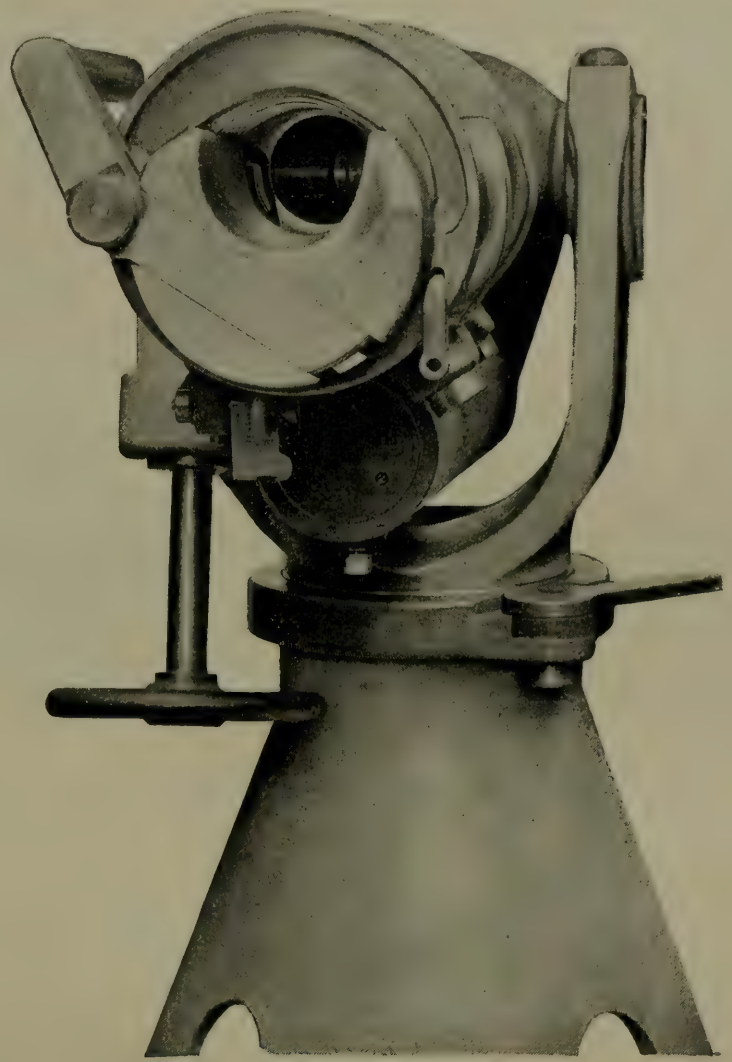
Date.	Weight of shell.		Weight of charge.		Kind of powder.	Muzzle velocity.		Pressure in bore.	
	Kilos.	*Pounds.*	*Kilos.*	*Pounds.*		*Meters.*	*Feet.*	*Kilos per sq. cm.*	*Tons per sq. in.*
Aug. 27, 1892.	13	28.66	5	11.02	Brown prismatic	577	1,893	1,052	6.68
	13	28.66	8	17.64	....do	719	2,359	1,946	12.35
	13	28.66	10.025	22.10	....do	826	2,710	2,437	15.47
	19.8	43.65	9.4	20.72	....do	674	2,211	2,497	15.85
Sept. 20, 1892.	13	28.66	4.8	10.58	Smokeless, Type I	911	2,989	2,117	13.44
	12.9	28.44	4.9	10.80	....do	930	3.051	2,259	14.34
	13	28.66	5	11.02	....do	933	3,061	2,276	14.47
	13	28.66	5.1	11.24	....do	950	3,117	2,372	15.06
	12.8	28.33	5.3	11.68	....do	979	3,212	2,512	15.95
	13	28.66	5.5	12.12	....do	1,008	3,307	2,789	17.71
	13	28.66	5.6	12.35	....do	1,026	3,366	2,979	18.91
	13	28.66	5.4	12.12	Smokeless, Type II.	891	2,923	1,936	12.29
	13	28.66	5.6	12.35	....do	901	2,956	1,921	12.20
	13	28.66	5.8	12.79	....do	937	3,074	2,094	13.30
	13	28.66	6	13.23	....do	954	3,130	2,195	13.94
	13	28.66	6.2	13.67	....do	977	3,205	2,430	15.43
	13	28.68	6.4	14.11	....do	1,002	3,287	2,523	16.02
	13	28.66	6.2	13.67	Smokeless, Type III	864	2,834	1,875	11.90
	13	28.66	6.4	14.11	....do	892	2,926	1,984	12.60
	12.98	28.61	6.7	14.77	....do	921	3,021	2,152	13.05
Apr. 26, 1893.	13	28.66	5.9	13	BN_1	Four shots with aim during 29 seconds.			
	13	28.66	5.9	13	....do	887	2,910	2,248	14.27
	13	28.66	5.9	13	....do	886	2,906	2,190	13.90
May 13, 1893.	13	28.66	5.15	11.35	Smokeless, Type I	967	3,172	2,519	15.99
	13	28.66	5.15	11.35	....do	980	3,215	2,516	15.98
	13	28.66	5.15	11.35	....do	966	3,169	2,538	16.12
	13	28.66	6.15	13.56	Smokeless, Type II.	955	3,133	2,362	14.99
	13	28.66	6.15	13.56	....do	967	3,172	2,419	15.36
	13	28.66	6.15	13.56	....do	966	3,169	2,442	15.50
	13	28.66	6.5	14.33	....do	996	3,267	2,735	17.37
	13	28.66	6.6	14.55	....do	1,006	3,301	2,785	17.68

NEW NORDENFELT R. F. G.

A new Nordenfelt 57-millimeter (2.24-inch) R. F. G. was experimented with at the proving ground at Sevran Livry during the summer of 1892 by a French naval commission. Extraordinary pressures were employed and the system was reported to present some important advantages. Two series of 10 shots each were fired with pressures ranging from 16.68 tons to 27.37 tons per square inch, which were intended to severely try the breech mechanism. The breech closure performed well, opening easily after each discharge. The chamber was made to receive the regulation cartridge case, but a smaller chamber is in contemplation and it is intended to obtain more expansion volumes and nearly equal velocities with a reduced charge.

As a result of the trials, the French authorities are building a 65-millimeter (2.56 inch) R. F. G. under this system, and have in con-

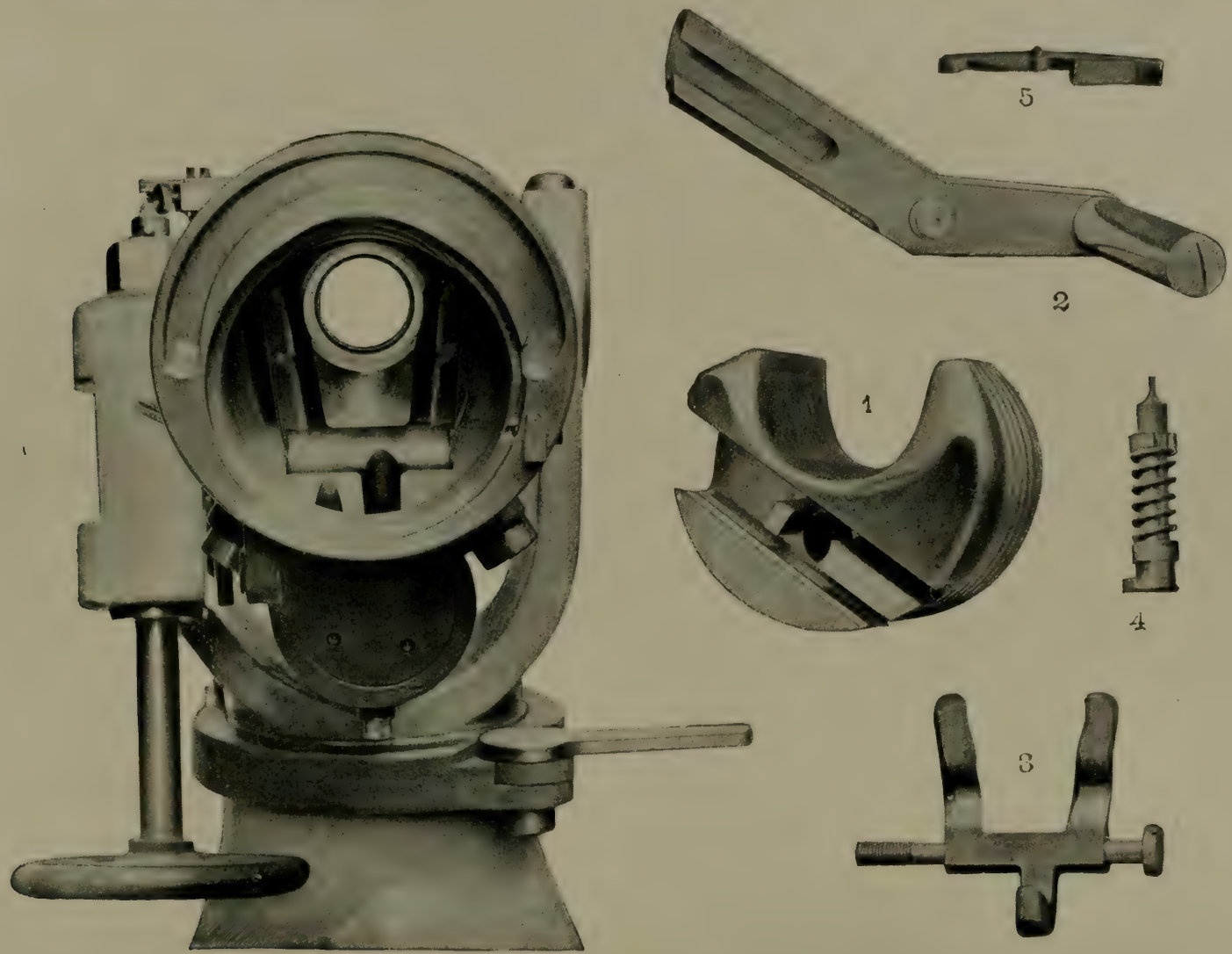
Breech closed.



Breech open.

NEW NORDENFELT BREECH MECHANISM.

Revue de L'Armée Belge.



DETAILS OF NEW NORDENFELT BREECH MECHANISM.

Revue de L'Armée Belge.

sideration a 100-millimeter (3.94-inch) gun. The length of the 57-millimeter gun is 36 calibers in the bore, and its total length, 7.1 feet.

The breech closure is of the screw system, with continuous threads, those of the block being only interrupted for a short distance, and the block never leaves its bearing when the breech is opened.

The block is eccentric, its axis not being in the prolongation of the bore.

The action of the mechanism is clearly set forth by the illustrations. In the Pl. 18, fig. 1, is the breech plug; fig. 2, the maneuvring lever; fig. 3, the extractor; fig. 4, the firing pin and its spring; fig. 5, the trigger.

HOTCHKISS 6-POUNDER R. F. G. OF 50 CALIBERS.

This gun is specially designed for the use of smokeless powder, with a view of materially increasing the power and efficiency of naval secondary batteries without an undue increase of dead weight.

Weight of gun	pounds	1,144
Length of bore	calibers	50
Maximum powder pressure	tons per square inch	16
Weight of—		
Shell	pounds	6
Charge	do	1.98
Complete cartridge	do	10.3
Initial velocity	feet	2,625
Velocity at 1,000 yards	do	1,961
Angle of elevation for 1,000 yards	minutes	29.5

The velocity of the shell at 1,000 yards with the 50-caliber gun, using smokeless powder, is greater than the velocity at the muzzle of the heavy 6-pounder, using black powder. The weight of charge is nearly the same for both guns, but the chamber of the 50-caliber gun being much larger, gives an ample density of loading, which limits the maximum pressure to the same amount in both guns.

The flatness of trajectory is such that if the sight be given a certain fixed elevation and the gun aimed at the water line of a torpedo boat the projectile will strike the boat at any range from the muzzle to over 1,200 yards. This permits more rapid and accurate fire, as the gunner is relieved from all adjustment of the sights and can devote himself entirely to the care of keeping the gun on the target.

The mount for this gun is of a new design and consists of a cradle, pivot, and base plate, which may be mounted either on a pedestal or directly on a ship's rail. The cradle is a single bronze casting, forming a sleeve to receive and guide the gun; this sleeve carries the trunnions. The hydraulic cylinder is attached on top of the cradle, whilst underneath is placed a telescopic cylinder containing the spring for returning the gun to battery. As in all Hotchkiss recoil mounts, the spring and hydraulic cylinders are kept separate in order that an accident to a spring may not cripple the gun, and that springs may be replaced in a

few seconds. The pivot and base plate are connected by a circular clip. The breech mechanism is of the old standard pattern, except that there are two extractors; a half cock is provided for the sear; a recocking lever is attached to the rocking shaft; a safety lock is provided to guard against hangfires; there is no pistol grip. Both the rear and front sights have been arranged to be readily removed from the gun. The deflection slide is marked in knots for compensating for speed of moving target. On the deflection slide is mounted a folding leaf, which, when raised, gives the proper elevation for any range up to 1,200 yards for repelling torpedo-boat attacks. Grenfell's illuminated sights are provided for night firing. The weight of the carriage complete, without the pedestal or shield, is 627 pounds. The weight of the shield is 825 pounds.

Several different models of Hotchkiss 6-pounder guns are in service in the various navies of the world.

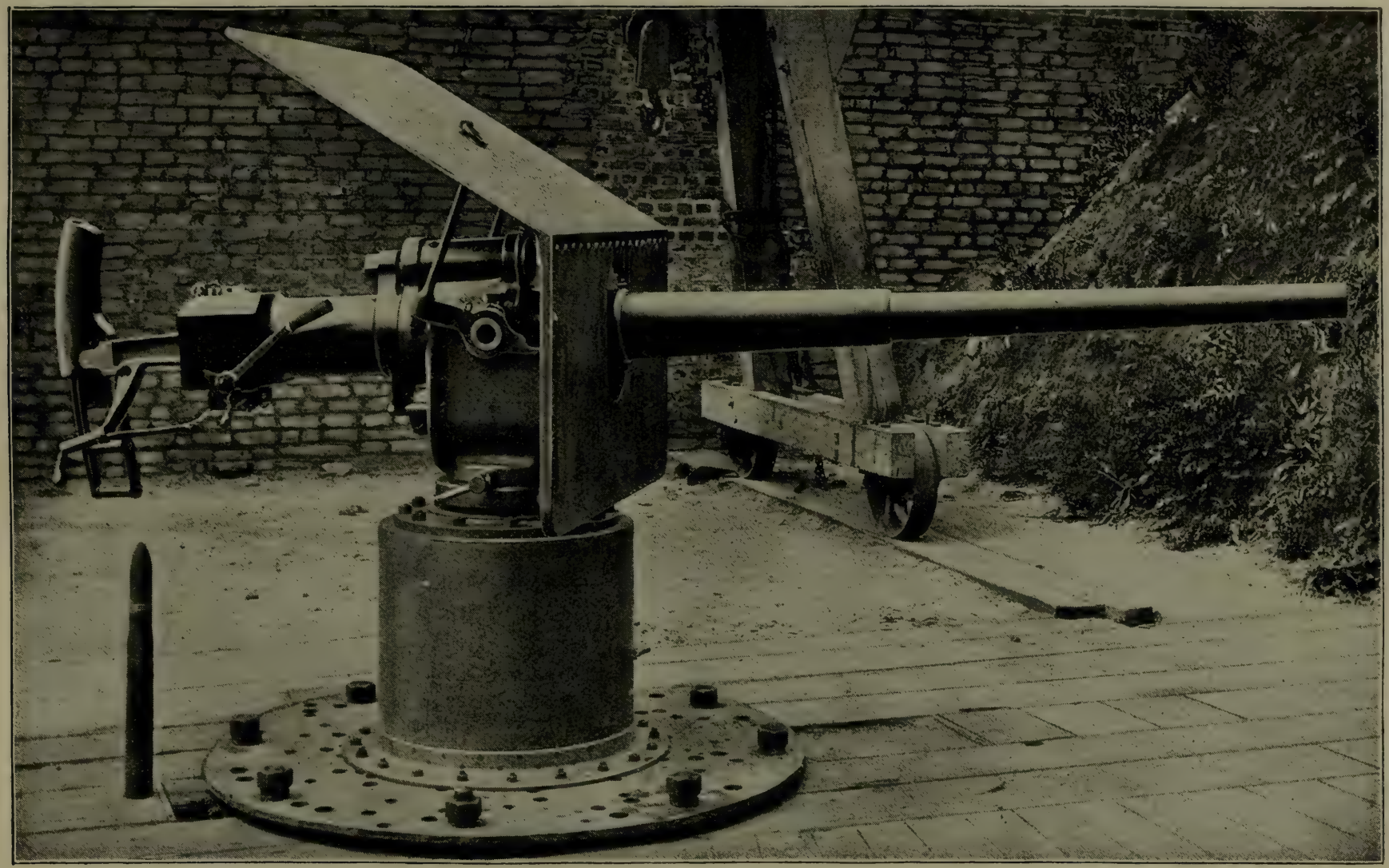
The original model gun has a length of bore of 40 calibers, and may be distinguished by carrying trunnions and having a pistol grip at the rear of the breech. The breech mechanism is of the old standard model. The rear sight is of the Hotchkiss common-bar type. The pivot and mount are of the non-recoil model, or of the Armstrong double-cylinder recoil type.

Weight of gun	pounds	803
Weight of nonrecoil mount	do	519
Weight of shield	do	135
Initial velocity of projectile	feet	1,820

The later model gun has a length of bore of 45 calibers. It has no trunnions, a screw thread being worked at the center of weight for screwing the gun into its recoil mount. The breech mechanism is either of the old standard, but without pistol grip, or is of the 1893 model. The rear sights are either the Stuart or the Parkhurst automatic clamp patterns. The recoil mount is the Fletcher single-cylinder type, secured to the gun with the cylinder lying in the pivot fork underneath the gun.

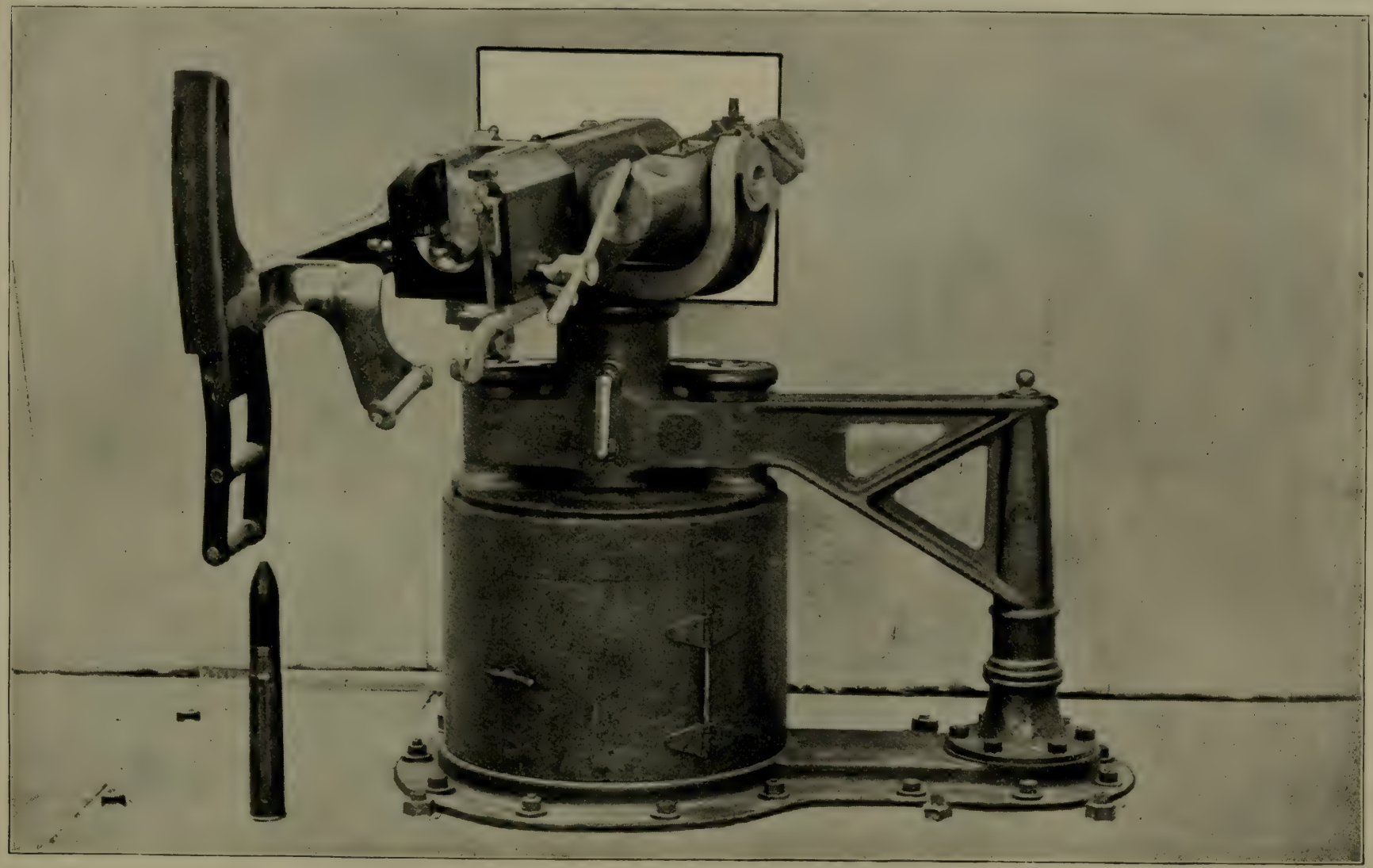
Weight of gun	Pounds	805
Weight of recoil mount	do	1,198
Weight of shield	do	290
Initial velocity of projectile	Feet	1,870

An excellent mount for this gun is the crane mount, which permits the gun to be completely housed. A stout crane is mounted at one side of the pedestal proper, carying on its arm the entire recoil pivot. Springing from the top of the pedestal is a half housing, into which the solid casting of the pivot socket swings, where it is held by stout bolts on each side. The pedestal forms a closet for accessories of the gun.



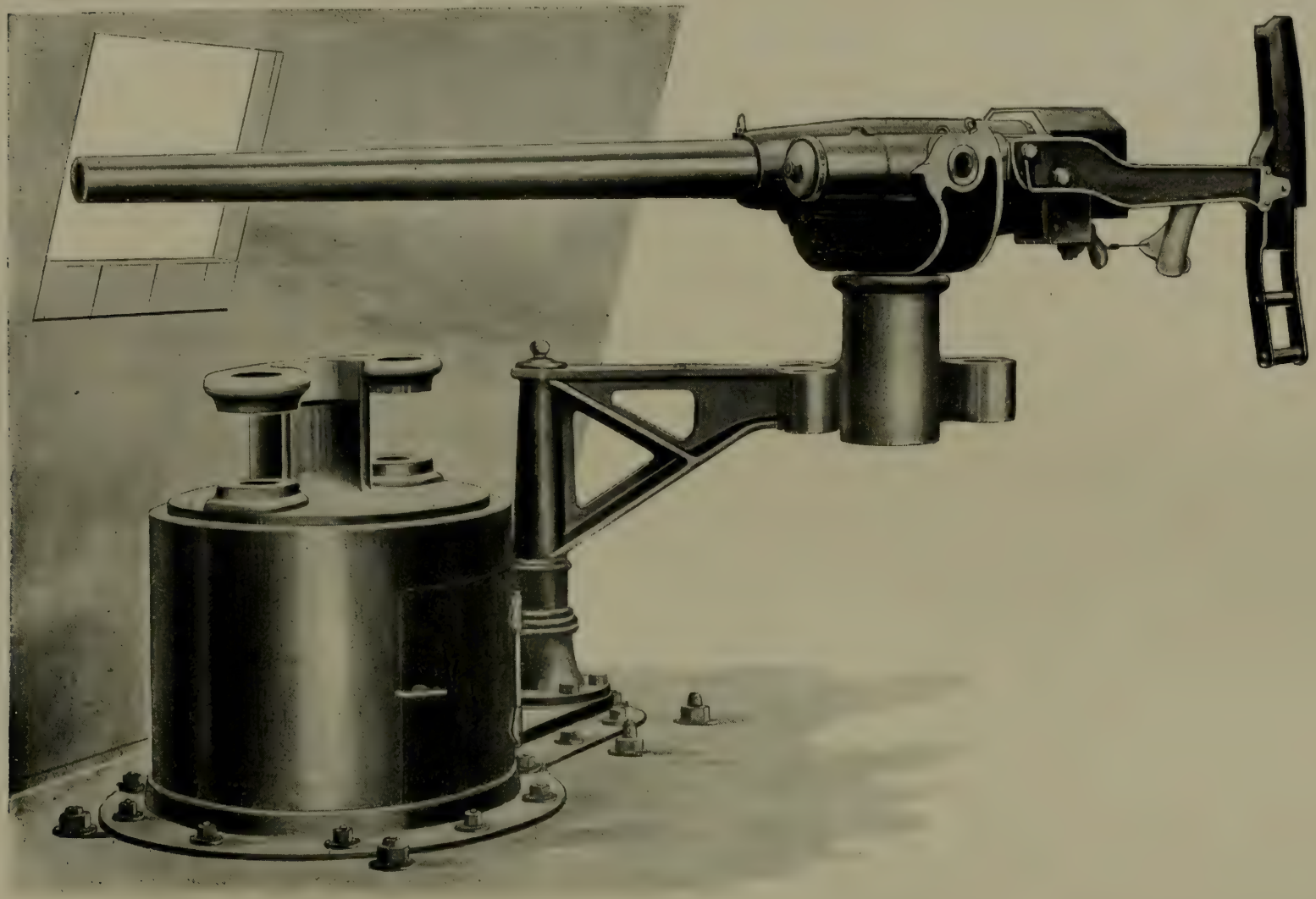
HOTCHKISS 6-POUNDER R. F. GUN L/50 WITH RECOIL MOUNT.

Hotchkiss Catalogue.



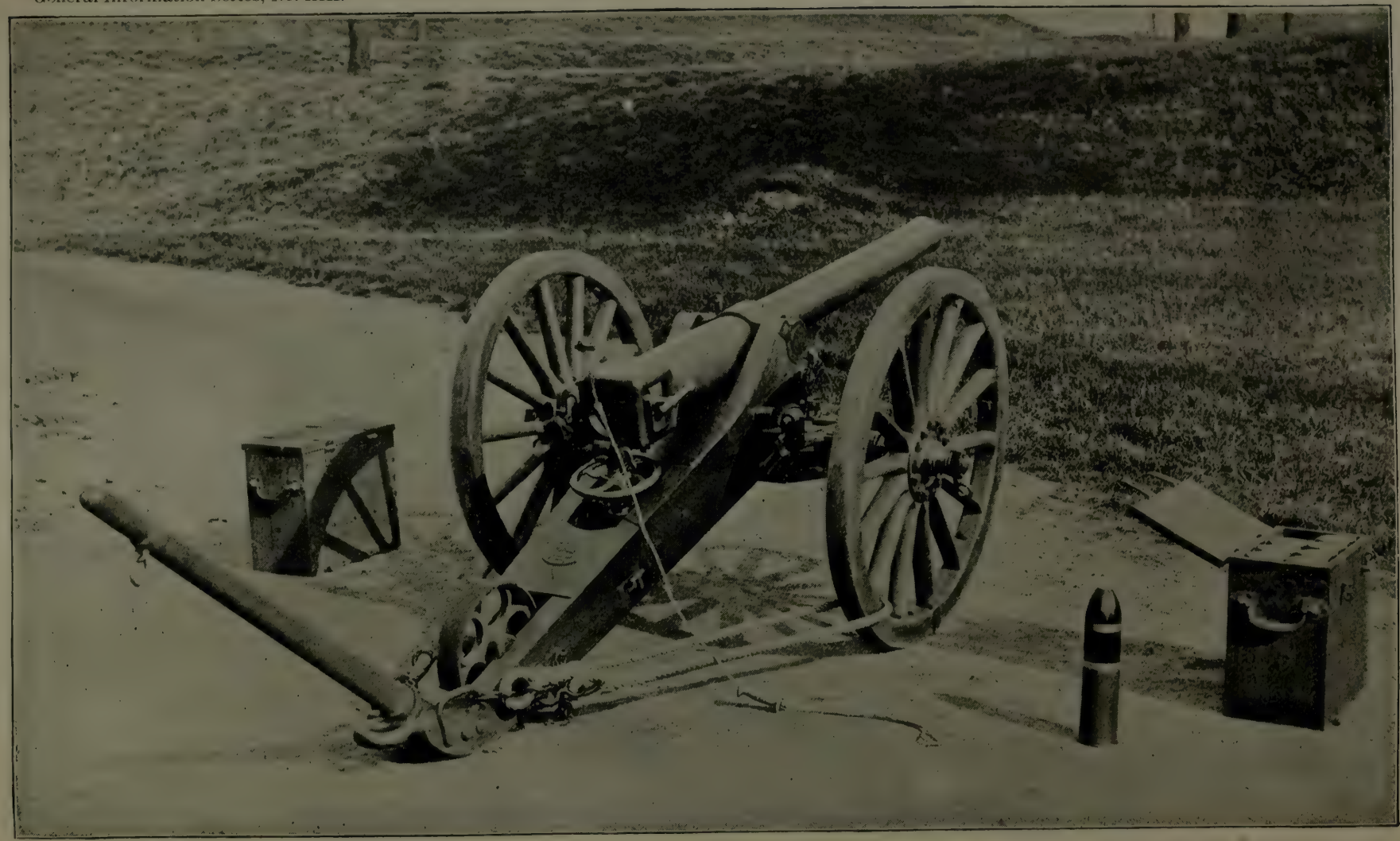
HOTCHKISS 6-POUNDER R. F. GUN ON CRANE MOUNT, IN BATTERY.

Hotchkiss Catalogue.



HOTCHKISS 6-POUNDER R. F. GUN ON CRANE MOUNT, SHOWING METHOD OF HOUSING.

Hotchkiss Catalogue.



HOTCHKISS 10-POUNDER NAVAL LANDING GUN, IN BATTERY.

Catalogue Hotchkiss Company.

HOTCHKISS 10-POUNDER, NAVAL LANDING GUN.

This gun is designed for naval landing service and is intended to give a thoroughly effective shrapnel fire, although its weight is within the limit of hand draft. The gun is not high powered, its length being only 23 calibers.

The body of the gun is a single forging of oil-tempered and annealed steel. The trunnion ring is screwed on the gun body just forward of the reenforce, and provides a support for the fore sight. The bore is rifled with a uniform right-hand twist. The lands are very narrow in proportion to the grooves and are 24 in number. The breech mechanism is designed for the use of friction primers in connection with metallic ammunition, and is simple and strong. The component parts are: (1) Breechblock; (2) stop bolt; (3) stop-bolt washer; (4) manœuvring handle; (5) locking screw; (6) locking-screw pin; (7) extractor; a total of seven parts. A percussion lock is fitted when desired.

The breechblock is a solid prismatic steel block with rounded corners, having a horizontal movement in a mortice cut completely through the breech of the gun. The front face of the block is perpendicular to the axis of the bore, whilst its rear face is slightly inclined. The left end of the block is bored to form a prolongation of the chamber when the breech is open, and its front upper corner is cut away to allow free movement for the extractor.

The horizontal movement of the breechblock is limited by the stop bolt, which, passing through the lower part of the breech housing, engages in a guide in the lower part of the block.

In the right end of the breechblock is a shaft, on which is secured the locking screw and which terminates in a handle. The thread of of the locking screw is cut away for about 100 degrees, so that the breechblock may be locked or unlocked by a half turn of the handle.

The extractor is a single piece of steel working in a longitudinal groove in the top of the breech mortice. Its forward end is formed into a claw to grasp the head of the cartridge. On the same side as the claw is a stud which, following a guide in the top of the breechblock, imparts motion to the extractor.

The vent is a cylindrical channel passing diagonally through the breech and breechblock, and changing direction in the block so as to follow the axis of the bore.

The front sight is of the open type, allowing a large field of view. The tangent sight is provided with a sliding head, by means of which it may be set before being placed on the gun, and with a deflection slide for making allowance for wind, etc. On this slide there is an open notch for rough and a peep sight for fine sighting. The sight bar is graduated on one side in ranges and on the other in millimeters.

The action of the mechanism is as follows: The gun having been fired, the handle is turned to the rear, unlocking the block and start-

ing it in the mortice. Drawing the handle smartly to the right, the breech is opened. The extractor, actuated by the movement of the block, moves slowly back, starting the cartridge case from the chamber, and when the breechblock has moved sufficiently to unmask the bore, the extractor makes a quick movement to the rear and ejects the cartridge case. A new charge being inserted, is pushed home until the head of the cartridge case brings up against the extractor. The breech is now closed by pushing it smartly to the left, and is locked by turning the handle to the front. When a primer is inserted the gun is ready for firing. It is impossible to fire before the breech is closed, as until then the portions of the vent in breech and breechblock are not in communication.

The carriage is fitted with a trail wheel to permit manœuvring without the limber, and carries 2 boxes of ammunition. The limber is fitted to carry 4 boxes of ammunition, making a total of 48 rounds carried.

Some particulars of the gun, etc.

Weight of gun	pounds	363
Caliber	inches	3
Length of bore	calibers	21.5
Number of grooves		24
Angle of rifling	degrees	6
Weight of—		
Carriage	pounds	560
Limber, with ammunition, tools, and accessories, for hand draft	do	1,078
Carriage, accessories, and ammunition, complete for hand draft	do	1,255
Carriage, limber, ammunition (48 rounds), and accessories for horse draft	pounds	2,333
Projectile	do	10
Charge	do	1.32
Initial velocity	foot seconds	1,200

SCHNEIDER & CO.'S 15-CENTIMETER R. F. G.

The advantages claimed for this gun by the designers are as follows:

(1) Very high ballistic power.

(2) Breech mechanism of simple manipulation, with firing devices arranged for percussion or by electrical contact.

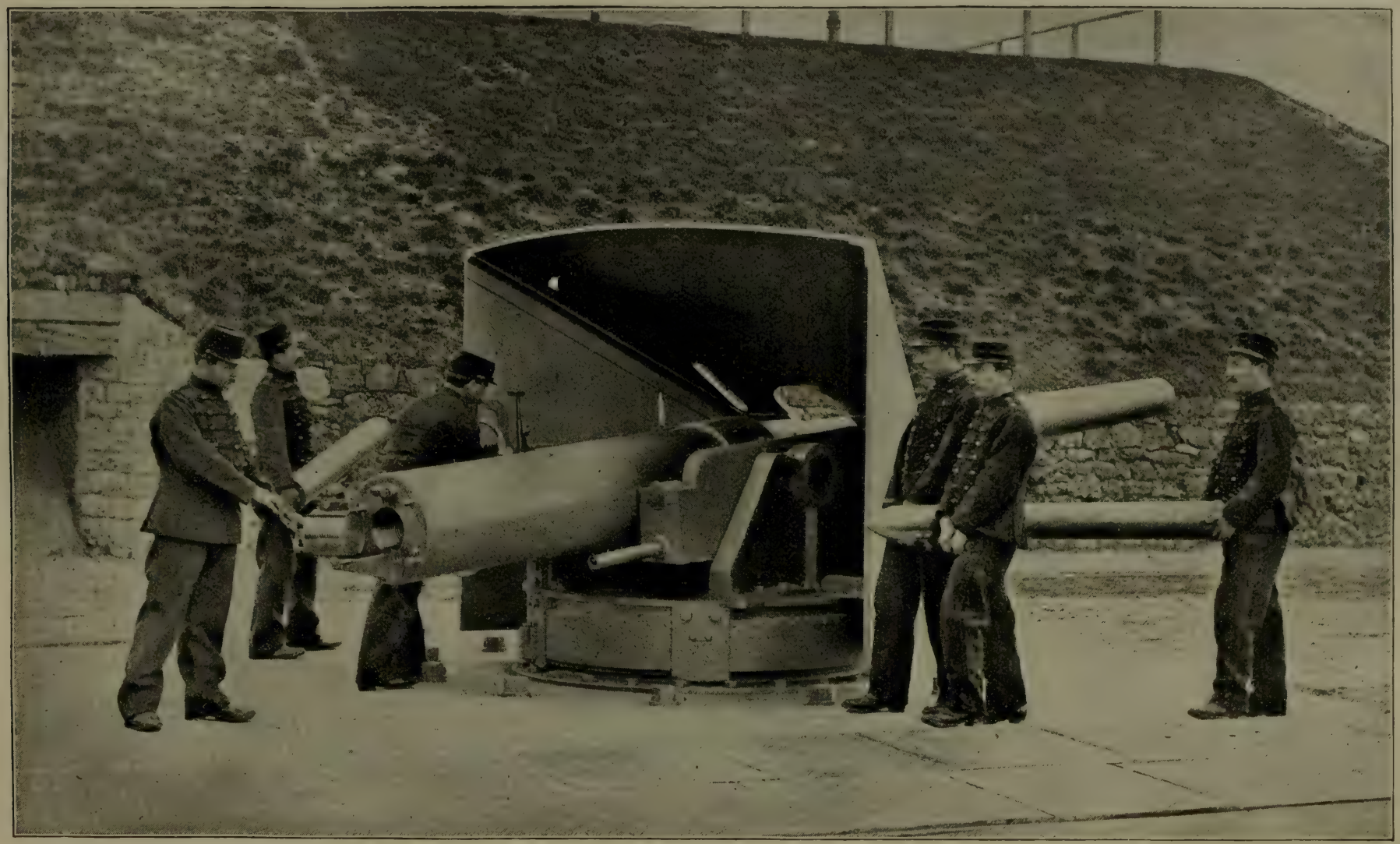
(3) Simplicity of construction and management, and strength of the various parts.

(4) The use of metallic cartridges.

(5) The employment of a simple extracting device.

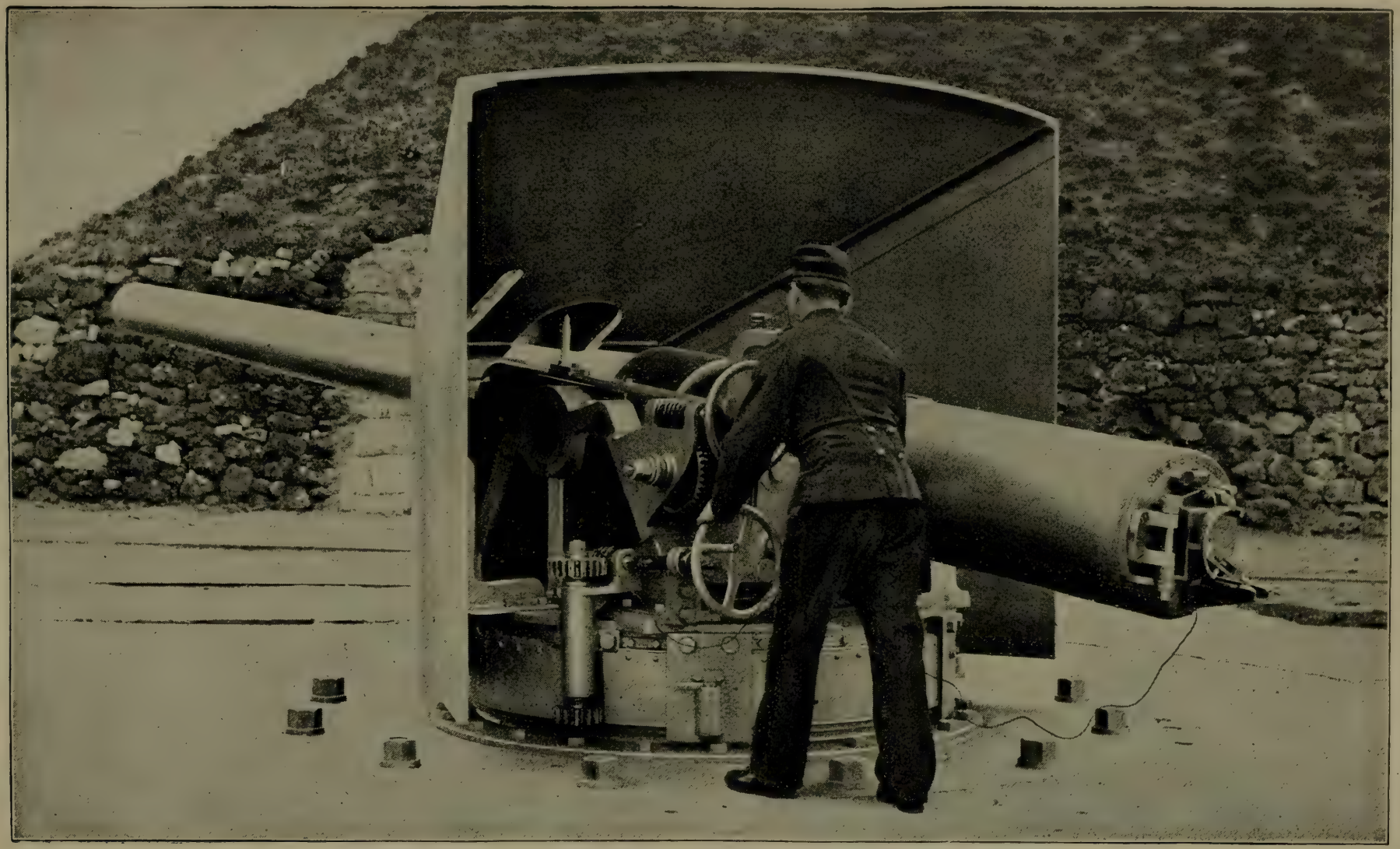
(6) The adoption of a safety apparatus for preventing firing before the complete closing of the breech, and for opening the breech in case of a missfire.

The gun is built up of forged, tempered, and annealed steel tubes of the quality that conforms with the specifications of the French marine. The length is 45 calibers and the weight is 5.5 tons. It includes an inner tube extending for the whole length of the gun, and into the end



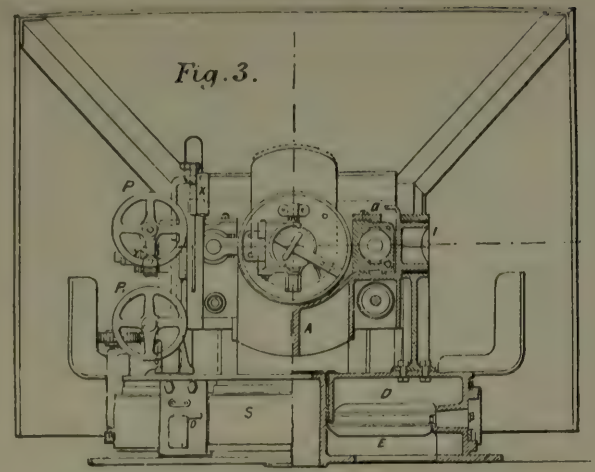
SCHNEIDER 15cm. R. F. GUN L/45, WITH CENTRAL PIVOT MOUNT. LOADING THE GUN.

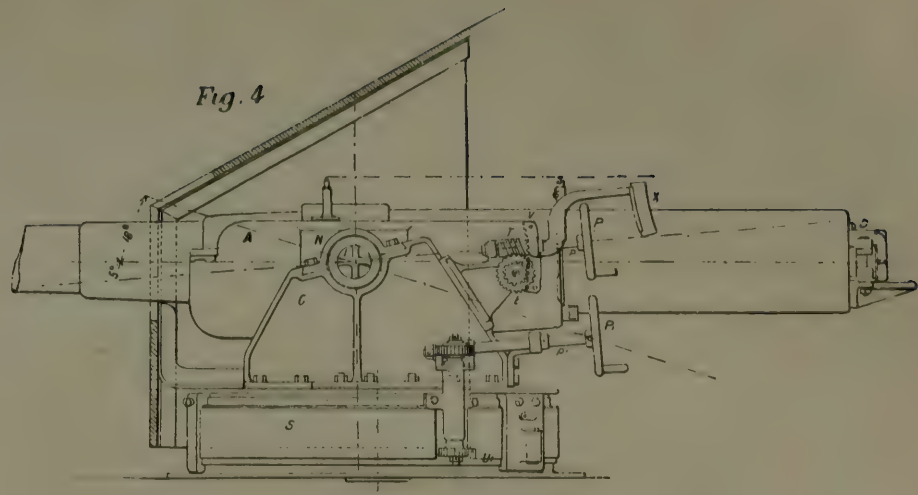
Schneider & Co.

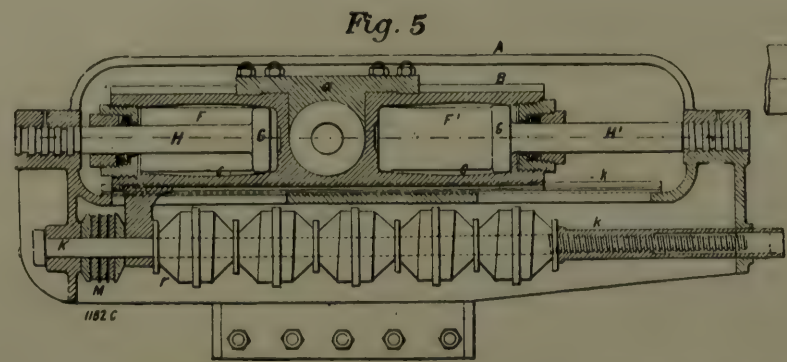


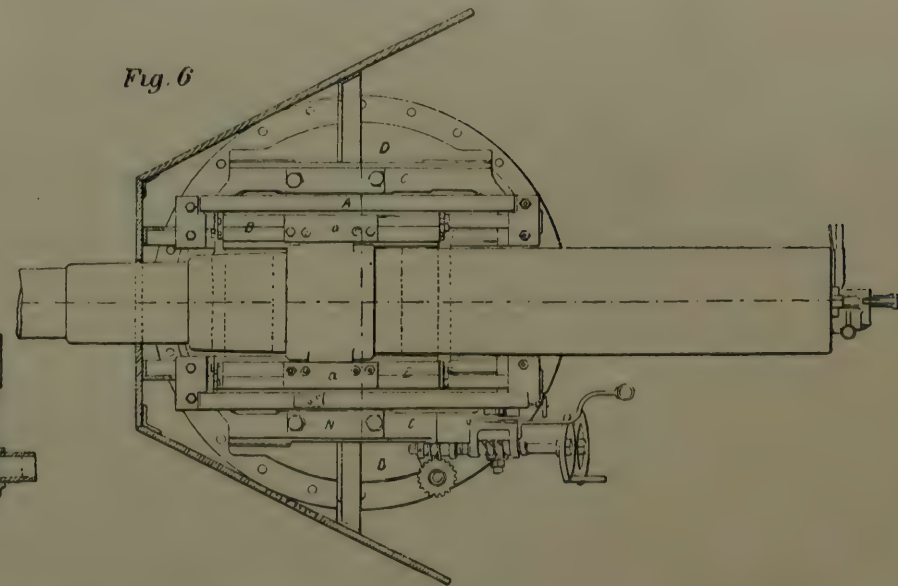
SCHNEIDER 15cm, R. F. GUN L/45 WITH CENTRAL PIVOT MOUNT. FIRING POSITION.

Schneider & Co.









DETAILS OF CARRIAGE FOR 15-CENT. GUN.

of which the breechblock is screwed. An outer tube covering the inner one strengthens the rear as far as the trunnion ring.

A series of outer rings over the latter tube, and some lighter rings extending from the trunnions to the muzzle, complete the structure. The gun is designed for the use of metallic cartridges, and for this reason no obturating mechanism is necessary, the cartridge case being sufficient to check the escape of gases to the rear by its expansion. The chamber is formed to fit the cartridge and also to receive a projectile furnished with centering and rifling rings. The rifling consists of 48 grooves of varying pitch, commencing at 2 degrees and finishing at 7 degrees; the depth of the grooves is 1 millimeter (.039 inches) and the diameter between the lands is 150 millimeters (5.9 inches).

The breech-closing mechanism is of the Schneider system, in which the breechblock, with an interrupted screw thread of three equal sectors, is employed, together with a bronze bracket and a double latch that keeps the bracket solidly fixed either to the gun or to the breechblock.

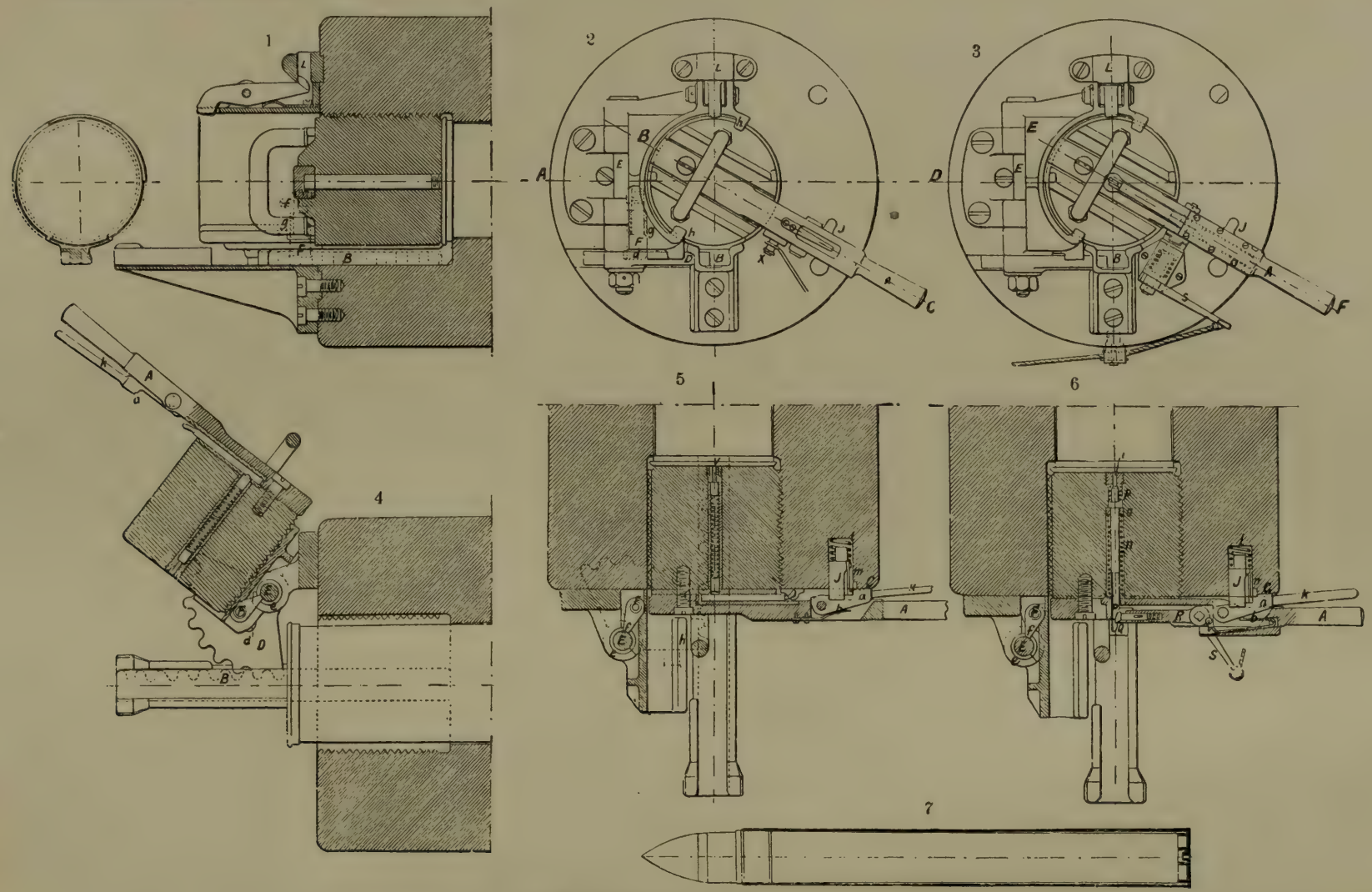
Manipulation of the breechblock is effected by means of the lever A, figs. 1, 2, and 3, and a cam *a* is pressed by the spring *b* into the groove C at the back of the breech in order to prevent the breechblock from becoming free. The extractor consists of a strong rectangular bar B, provided in front with a gripping claw and with lateral teeth. A toothed sector turning on the hinge E gears always with the extractor and has a recess *d* in which the finger F, fixed upon a bracket, can enter. This finger is placed vertically, and has at its upper end a projection which bears constantly on an incline *e* upon the hinge, by means of a spring *g*. The breech being closed, the various parts occupy the positions shown in figs. 1, 2, and 3. The extractor claw is a little in advance of the base of the metallic cartridge, as will be seen in fig. 1. By taking the lever A and moving it round one-sixth of a turn, and at the same time by holding the small lever K, the cam *a* that locks the lever A is released. After the breechblock is set free it is drawn towards the aperture by pulling on the lever A and the handle K; the breechblock, guided by the guides *h*, strikes at the end of its movement the front faces of these guides. The shock resulting from this sets free the double latch, and at the same time the rear point of the latch engages in the breechblock, and the finger F enters the recess in the toothed sector B. By pulling sharply on the lever A the bracket and the breechblock turn round the hinged axis, and at the commencement of the rotation the finger F strikes the toothed sector of the extractor, the shock having the effect of loosening the metallic cartridge case. As the movement of turning the bracket continues, the finger draws with it the toothed sector and the extractor bar, at the same time the slope *e* on the hinge raises the point *f* of the finger F, and this latter becomes disengaged from the toothed sector and leaves it shortly before the rotation of the bracket is completed; but by this time the extractor has been moved so far that the metallic cartridge

case, which has moved with it, has been withdrawn some inches from the end of the gun. One of the operators then pulls out the case and others put the new cartridge into the gun. The flange of this cartridge engages in the end of the extractor and moves it forward into the gun in such a way that the extractor bar returns easily to its initial position. The breech is then closed by the ordinary movement, the lever A goes back to its original position shown in figs. 2 and 3, and the cam *a* enters the recess, locking the breechblock.

When the breech is closed the small block J, actuated by the spring I, placed on the back of the gun, locks the lever and prevents any further movement. At the side of the block is a small spring finger *m*. When the gun is fired recoil takes place suddenly, the small block by its inertia enters a recess in the gun and releases the lever, the spring finger on which, engaged in the small recess, is so arranged as to prevent any further movement; it is then possible to manipulate the lever and to open the breech. On the other hand, if the gun hangs fire no recoil takes place, and the block remains in its normal position over the lever, which can not be manipulated by the operator until the block is pressed by hand and the lever released.

The gun can be fired either by percussion or by electricity; the former method is represented in figs. 5 and 6 and the latter in figs. 1, 2 and 3. In each case the operation is entirely under the control of the man serving the gun, and firing is absolutely impossible unless the breech is completely closed. The apparatus for firing with percussion fuses consists essentially of a striker actuated by the coiled spring of the lock and the trigger controlling this lock. The striker N and its actuating spring *n* are placed in the axis of the breech-block, the needle *i* of the striker moves in a hole in the block, and in its normal position is flush with the forward face of the breech-block; this position is maintained by the collar of the spring *o* and by the returning spring *p*.

At the rear end of the striker is the groove P, in which works the spring detent Q mounted on the lever R. The axis of this lever can be rotated by the T-shaped head that engages in a grooved path formed at the back of the gun. It is controlled by the lever S, to which is attached one end of the firing cord, the other end being held by the man serving the gun. The spiral spring mounted on a key and the flat spring attached to the firing lever, restore all the various parts to their normal positions. By this arrangement the operator by drawing on the cord sets the striker by means of the lever R; the spring detent Q becomes free of the striker when this lever is drawn sufficiently far back, and under the action of the spring *n* the needle of the striker is thrown forward against the percussion fuse placed in the center of the base of the metallic cartridge case. In the event of a missfire the operator can reset the striker by pulling a second time on the firing cord. It will be remarked that the lever R is mounted on the main lever of the breech-block, and that the controlling key is fixed to the breech of the gun; firing, therefore, can only take place when the main



DETAILS OF BREECH MECHANISM FOR 15-CENT. GUN.

lever of the breech is in its proper position, that is to say, when the breech is completely closed.

When firing by electricity is preferred, the striker and spring devices are replaced by an insulated needle, which by means of a coiled spring is made to project slightly from the forward face of the breech-block. The main lever carrying the firing lever and the detent is replaced by another, to which is attached an insulated conductor, and when the breech is closed the needle V is in contact with the central part of the electric fuse placed in the base of the cartridge case. Electrical contact is made by the terminal X attached to the rear of the gun, and with which contact is made at the moment when the breech is locked, by an insulated conductor on the main lever, and which then connects with the needle V. One of the wires from the battery is attached to the terminal X; the other wire is in contact with the gun and its mounting, and so long as the breech is not completely closed the contact with the conductor of the main lever does not take place, the circuit remains open, and the gun can not be fired. The operation is completed by means of a circuit-closer operated at will by the man serving the gun. In order to avoid missfire all the contacts are made of silver.

The ammunition is contained in a metallic cartridge case the percussion and electric fuse being carried in the base of the case. The charge is fired by means of a small priming of black powder. The projectile is forced into the open end of the cartridge case for a sufficient distance to insure firm contact. The projectiles employed weigh 88.2 pounds, and are of three kinds—cast-iron shell, chrome-steel shell, and mitraille shell. All of these projectiles are fitted with red copper bands to take the rifling.

The personnel necessary for working the gun is as follows: (1) One pointer. (2) One man who opens and closes the breech. (3) Three men for feeding. (4) One man for withdrawing the empty cartrideg case.

When the target aimed at is a rapidly moving one, No. 1 fires the gun, but for quick firing at a fixed target or at a slowly moving object the work devolves upon No. 2. The maximum rapidity of firing without pointing is about 10 rounds per minute.

The carriage upon which this gun is mounted is of the central-pivot type with small recoil and automatic return. It can be placed equally well on board ship or mounted on a coast battery. The carriage consists essentially of an oscillating cradle A, of two slides with brake cylinders B, of the frame C and D, and of the under carriage E. It is also furnished with a steel shield. The total weight of the carriage without the shield is about 4.7 tons; the weight of the shield is 2.5 tons, so that the weight of the carriage complete is about 7.2 tons.

The carriage has been designed with the intention of fulfilling the following conditions:

(1) To reduce the amount of recoil to the lowest possible limits, and to insure a rapid and automatic return so as to secure rapid firing.

(2) To do away with the effect of percussion in all positions of the gun by making it recoil on its axial line, and by opposing the direct action of the brake.

(3) To distribute the effects of firing over a large surface in order to reduce the strains on the various parts.

(4) To allow the man pointing the gun to effect this manœuvre rapidly both for elevation and direction, while at the same time he can fire the gun himself, although he has nothing to do with loading it.

The carriage is of a very strong and simple construction, and does not require any preparatory manipulation for putting it in service. The gun is maintained constantly in firing position by springs; the brake cylinders are always full of liquid; the joints in this part of the mechanism are few in number, and so designed as to remain quite tight; under these conditions the gun is always ready for firing.

The body of the carriage is of cast steel; the cradle is formed of two parts bolted together in the middle and provided with trunnions that rest in bearings on the sides of the frame, and which carry the weight of the gun, the slides, and the cradle. The latter is formed of a strong casting, on the upper faces of which are bronze strips that serve as slides for the brake guides. The forward and rear ends of each of the girders are raised in such a way as to furnish points of attachment for the piston rods of the brake. The central rib provides the means of connecting the two sides of the cradle, at the same time giving it great rigidity. The lateral trunnions, which are cast with the cradle. are fitted with bronze rings.

The two brake cylinders are placed symmetrically on each side of the gun, and are operated in identically the same manner. On each of these is mounted with great accuracy the trunnion of the gun, consequently the cylinders follow all the recoil and forward movements of the gun. The trunnions are kept in place by a strap, as shown in the drawings. Two half collars in forged steel connect the two cylinders in front and at the back, and at the same time check any displacement of the gun around its trunnions. The cylinders F F^1 are of forged steel of precisely the same internal diameter and of the same length; the rear ends of these cylinders are in communication with each other by means of the passages *b b*. These pistons are shown at G G; their rods H H^1 are bolted, as already mentioned, to the raised ends of the cradle.

When the gun, after having been fired, forces back the cylinders, the pistons G G remain immovable; the liquid which is in front of each of these pistons is forced to the other side through the grooves cut within the cylinders; these grooves have a variable section determined in such a manner as to give a constant resistance during the whole length of the recoil, which has a maximum length of 253 millimeters (9.8 inches). During the recoil the partial vacuum, which would be formed in the front part of the cylinders by their movements along the piston rods H, is compensated by an equal quantity of liquid forced through the

passages *c c* by the piston rods H ' as the cylinders move forward upon them. In this manner the brake cylinders are always kept full, the loss in one being compensated by the excess in the other; this arrangement thus forms a constant volume brake, and a regular recoil without shock is secured. This system of coupled hydraulic brakes, with four cylinders, divides the effect of the recoil over four points of the frame by means of the four piston rods, two of which work in compression and two in tension. The division of the strains due to firing considerably diminishes the length of recoil; at the same time the dimensions of the brake are very small.

Fig. 5 shows the arrangement for bringing the gun back into the firing position automatically by means of a power-storing device formed of two sets of direct-acting springs. Beneath each of the brake cylinders and at the forward end is a projection that serves as an abutment for the springs *r r*, mounted on the rod K. This rod is formed with a head at the forward end that bears on the projection made in the side of the bracket; a thread is cut on a considerable portion of the rod at the rear end, and by this means sufficient initial compression can be given to the springs to keep the brake cylinders and the gun fixed at the maximum angle of elevation. The compression nut K is guided in the groove at the rear part of the side of the cradle. Spiral springs are employed, ten in each group; they are separated by disks which prevent them from getting foul of each other. At the moment of recoil, these springs are compressed by the movement of the brake cylinders, and when recoil ceases, the energy thus stored up is utilized in bringing back the gun and the cylinders to their initial position. This return movement is regulated by the brake which works in a manner inverse to that set up by the recoil, and any resulting shock is almost entirely absorbed by the buffers M placed at the forward part of the carriage. These buffers, made of disks of leather alternating with disks of iron, are mounted on the rods K, between two circular plates of heavier section at each end.

The bedplate D, to which the sides of the frame C are solidly bolted, is formed of a circular cast-steel plate. In the center is a recess which receives the pivot of the under carriage, and round which is made the rolling path for 24 conical rollers which bear on a suitable surface in the bottom of the under carriage, and turn freely, but their distance apart and their radial position are maintained by two concentric rings in which the spindles of the rollers take their bearings. A large catch in front and two smaller ones at the back, fixed to the bedplate, and engaging in the back of the under carriage prevent the frame from lifting during the recoil. One of the rear catches carries the locking bolt O intended to keep the frame in any desired position when the gun is not in service. The covering plate S surrounds the bedplate and under carriage, and shields the roller paths and conical rollers.

The maximum elevation of the gun is 23 degrees (from — 5 degrees to

+ 18 degrees). This is obtained by turning the cradle of the carriage around its trunnions. The movement is controlled by means of the handwheel P that operates the shaft *p* mounted on the left side of the frame. This shaft turns the screw T, and the helicoidal wheel *t* and the pinion U, that gears with the toothed sector V, fixed in the left side of the cradle. The mechanism for elevating the gun is attached to those parts of the carriage which do not recoil, consequently the man training the gun is not obliged to release the handwheel at the moment of firing.

Training in direction through the complete circle is effected by means of the handwheel P^1, working the endless screw p^1. This latter operates the helicoidal wheel t^1, and the vertical pinion U^1, that gears with the toothed ring fixed round the saddle. The gun can be turned round the complete circle in 110 seconds.

The under carriage, the pivot of which is fitted with bronze rings, is fixed to the frame by means of 24 bolts, and is arranged to receive the steel-toothed ring just referred to.

The men serving the gun are protected behind a shield of steel 30 millimeters (1.18 inches) thick. The shield is attached to the bedplate in front and on each side by means of strong angle brackets; it has no connection at all with the sides of the frame, and can therefore be subjected to considerable damage by firing without affecting the working of the gun. The handwheels controlling the training mechanism are placed on the same side as the sights. In action the shoulder piece X, fixed in the same side on the frame, assists the man in training the gun, and who, while operating the training wheels, is thus able to follow more easily the displacements of the target and to keep the gun upon it.

The plates illustrate the mode of operation of the gun. The general dimensions and other particulars are as follows:

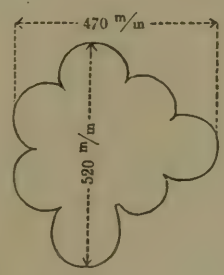
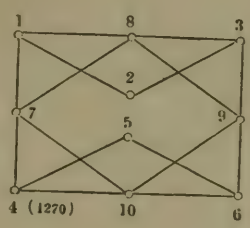
Total length of gun, 23 feet 3.75 inches.
Total length of gun in calibers, 45.
Weight of gun, including breechblock, 12,276 pounds.
Weight of projectile, 88 pounds.
Powder charge, P. B., 52.8 pounds; B. N. smokeless, 35.2 pounds.
Weight of empty cartridge case, 30.8 pounds.
Total weight of loaded cartridge with powder, P. B., 171.6 pounds.
Total weight of loaded cartridge with powder, B. N., 154 pounds.
Total length of cartridge with shell, 64.57 inches.
Initial velocity, with P. B. powder, 2.338 foot seconds.
Initial velocity, with smokeless powder, 2,690 foot seconds.

Ratio of weight of gun and weight of projectile $\frac{P}{p}$, 139.5.

Weight of carriage, without shield, 10,340 pounds.
Weight of shield, 5,500 pounds.
Amplitude of horizontal training, 360 degrees.
Time required for training the gun round the complete circle, 110 seconds.
Amplitude of training in elevation, — 5 to + 18 degrees.
Time required for maximum elevation, 12 seconds.
Height of trunnion above the deck, 39.37 inches.
Maximum recoil, 9.84 inches.

Messrs. Schneider & Co. report the following results of trials with the 15-centimeter R. F. G., at the Polygon, at Creuzot, on June 28, 1892, in the presence of a commission presided over by the director of artillery, Col. de la Rocque.

The target was located at a distance of 90 meters (295 feet).

Number of shots.	Projectiles.		Powder.		Density of charge.	Angle of fire.	Velocity attained at 197 feet.		Mean initial velocity.	Pressure at breech measured by 4 crusher gauges.	Recoil.	Observations.
	Class.	Weight.	Type.	Weight.			Chronograph No. 1.	Chronograph No. 2.				
		Lbs.		*Lbs.*		*Deg.*	*Feet.*	*Feet.*	*Feet.*	*Atmos.*	*Ins.*	
1	Cylinder.	88.2	B. N. 75	28.7	0.525	0	.....	.....	.....	.....	.....	Temperature, 78°
2	..do ...	88.2	B. 19	28.0	.510	0	2,532	2,542	2,601	2,538 2,407 2,465 2,453	8.8	
3	..do ...	88.2	B. 19	28.4	.520	0	2,608	2,598	2,667	2,602 2,615 2,465 2,602	8.8	
4	..do ...	88.2	B. 19	28.2	.515	0	2,591	2,585	2,654	2,489 2,538 2,525 2,602	8.7	
5	..do ...	88.2	B. 19	28.2	.515	0	2,585	2,591	2,654	2,501 2,489 2,577 2,538	8.7	
6	..do ...	88.2	B. 19	28.2	.515	0	Salvo of 10 shots aimed at the center of the target, gun diverted and re-aimed at each shot. Duration of salvo, 83 seconds.					
7	..do ...	88.2	B. 19	28.2	.515	0						
8	..do ...	88.2	B. 19	28.2	.515	0						
9	..do ...	88.2	B. 19	28.2	.515	0						
10	..do ...	88.2	B. 19	28.2	.515	0						
11	..do ...	88.2	B. 19	28.2	.515	0						
12	..do ...	88.2	B. 19	28.2	.515	0						
13	.do ...	88.2	B. 19	28.2	.515	0						
14	..do ...	88.2	B. 19	28.2	.515	0						
15	..do ...	88.2	B. 19	28.2	.515	0						
16	..do ...	88.2	B. 19	28.2	.515	0	Salvo of 10 shots upon a point varied at each shot. Duration of salvo, 109 seconds.					
17	..do ...	88.2	B. 19	28.2	.515	0						
18	..do ...	88.2	B. 19	28.2	.515	0						
19	..do ...	88.2	B. 19	28.2	.515	0						
20	..do ...	88.2	B. 19	28.2	.515	0						
21	..do ...	88.2	B. 19	28.2	.515	0						
22	..do ...	88.2	B. 19	28.2	.515	0						
23	..do ...	88.2	B. 19	28.2	.515	0						
24	..do ...	88.2	B. 19	28.2	.515	0						
25	..do ...	88.2	B. 19	28.2	.515	0						
26	Fictif.	110.2	B. N. 75	30.9	.565	+16						

In consequence of these trials, eight breech closures of this system have been ordered fitted to eight 138.6 millimeters (5.45 inches) R. F. G., which are to form a portion of the armament of the battleship *Charles Martel.*

In March, 1893, some private trials were had at the Creuzot Polygon, of a 12-centimeter (4.72-inch) R. F. G. of the same system, having the following particulars:

Length: Extreme	inches	236
In calibers		50
Weight: Complete	pounds	7,187
Projectile	do	48.5
Cartridge with B. N. powder and shell	do	87
Mount without shield	do	6,282
Shield	do	8,707
Thickness of shield	inches	2.8

The mean results obtained were as follows: Time required to fire 10 shots at a fixed target, rectifying the aim each time, 72 seconds; time necessary to fire 10 aimed shots at a variable target, 90 seconds.

Velocity obtained with charges of B. N. powder, varying from 18.2 pounds to 18.75 pounds, taken at 98.4 feet from the muzzle of gun, 801 meters (2,628 feet); velocity with same charges at muzzle, 818 meters 2,683 feet); pressure in chamber corresponding to that velocity, 17.9 tons per square inch.

The piece was afterward sent to the Chicago Exposition, so that there was no opportunity to have a series of trials before the commission.

The Canet R. F. mount of the 1893 pattern differs from those already in service, in the carriage. The bed is circular for center pivot guns, and in front pivot guns is in the form of a sector, the angle of which varies according to the conditions to be fulfilled. The bed pivot is encircled with a ball race. The lower carriage consists of two cheeks inserted in front and at the bottom. It revolves on a ball race on the bed in a central pivot mounting, and in a front pivot mounting on rollers on a curved racer.

The left cheek or bracket carries the gear for elevating and training, also the sights, and the electric battery for illuminating the sights at night, with the rheostat, etc. On the right cheek is the pump of the brake cylinder.

The top carriage is a ring fitted with a hydraulic-brake cylinder, and carrying the trunnions which rest in beds in the lower carriage. There is a hydraulic brake with spring recovery, comprising a brake cylinder with piston and center pin governing the passage of the liquid, a return valve and spring recovering gear for running up the gun after recoil.

The sighting arrangements are fitted for slow or quick movement and with electric-lighting gear.

The firing gear on the left cheek of the carriage comprises a firing pin and springs, with hand gear for working, close to the hand of the gun firer.

A new type of shield has recently been adopted in the French service for the Canet mounts. It is in two parts, one of which is secured to the deck, protecting the bed plate and lower portion of the mount, and the other part is attached to the mount and turns with it. The thickness varies, but some of those already fitted to the 100-millimeter (3.94-inch) guns of the *Bouvines* are 2.84 inches thick in the important portions.

The weights of the guns and mounts are stated as follows: 164.7-millimeter (6.48-inch) gun, 6.94 tons; mount, 7.56 tons; shield, movable, 4 tons; shield, fixed, 1.4 tons; total, 19.9 tons. 138.6-millimeter (5.46-inch) gun, 4.12 tons; mount, 4 tons; shield, movable, 3.28 tons; fixed, 1.7 tons; total, 13.1 tons. 100-millimeter (3.94-inch) gun, 1.55 tons; mount, 3.45 tons; shield, movable, 2.45; shield, fixed, 1.15 tons; total, 8.6 tons.

The mounts are compact, easily managed, and all the attachments for night pointing are convenient and efficient.

A recent order abolishes the use of shields on the smaller R. F. and machine guns.

GERMANY.

The German navy budget for 1894–'95 includes the following appropriations: Ordinary permanent allowance for ordnance and fortifications, 4,520,758 marks ($1,071,911.80); special estimate for guns and torpedoes, 7,236,800 marks ($1,721,358).

The ordnance exhibit of Herr Krupp's firm, of Essen, at the Chicago Exposition, was the most important ever made at any international exposition by a single manufacturer of ordnance. It comprised a large series of guns, ranging from the monster 120-ton gun to the smaller calibers of rapid-fire guns.

THE 42-CENTIMETER (16.54 INCH) GUN.

This gun was constructed for coast-defense service. The breech mechanism is of the standard Krupp type, with rounded sliding-wedge block, and the charge is fired by a friction primer. The principal particulars of the gun are as follows: Caliber, 16.54 inches; length of gun, 45.93 feet; length of bore, 41.66 feet; weight of gun, 120.46 tons; number of grooves, 120.

Four kinds of projectiles are supplied with the gun, viz, cast-iron shell, steel shell, armor-piercing projectiles, and shrapnel. The weights of these projectiles vary from 2,204 to 2,513 pounds.

Sixteen rounds have been fired from this gun, and the following results were obtained:

Weight of projectile, 2,204 pounds; powder charge, 903.8 pounds; initial velocity, 1,981 foot-seconds; range with 10.5 degrees elevation, 9,680 yards (5.5 miles).

The perforating power of the steel shell on wrought-iron armor plate is: At muzzle, 3.53 feet; at 3,281 yards, 3.26 feet; at 6,562 yards, 3.01 feet.

The gun was on a front pivot mount, the rear portion of which was supported on four rollers traversing on a curved roller path. There was an upper carriage moving on the inclined slides of the lower part of the mount. The elevation was given by means of hand-worked gearing engaging in a toothed quadrant attached to the side of the gun.

Training is effected by means of a pitched chain and gearing operating on the rear of the under frame. The recoil is absorbed by hydraulic presses, the cylinders of which are attached to the lower carriage while the piston rods are fastened to a cross frame on the upper carriage. A chain and windlass are used to run the gun out.

THE 30-CENTIMETER (12.01-INCH) GUN.

The particulars of the gun are as follows:

Caliber	inches	12.01
Length—		
Gun	feet	35.01
Bore	do	32.05
Weight of gun	tons	61.46
Number of grooves		68
Weight—		
Mount	tons	53.15
Shield	do	11.81

Four kinds of projectiles are used, and there are two types of each kind, the heavier weighing 1,003 pounds, and the lighter, 725.3 pounds. With the 1,003-pound projectile and 227.07 pounds of smokeless powder, an initial velocity of 2,234 foot-seconds is obtained. The total muzzle energy is 34,728 foot-tons, and the range, with 13 degrees elevation, is 11,975 yards. Penetrating power of armor-piercing shell in wrought iron at the muzzle is 45.66 inches, and in steel plate is 29.69 inches. At 2,187 yards these figures become 38.03 and 25.08.

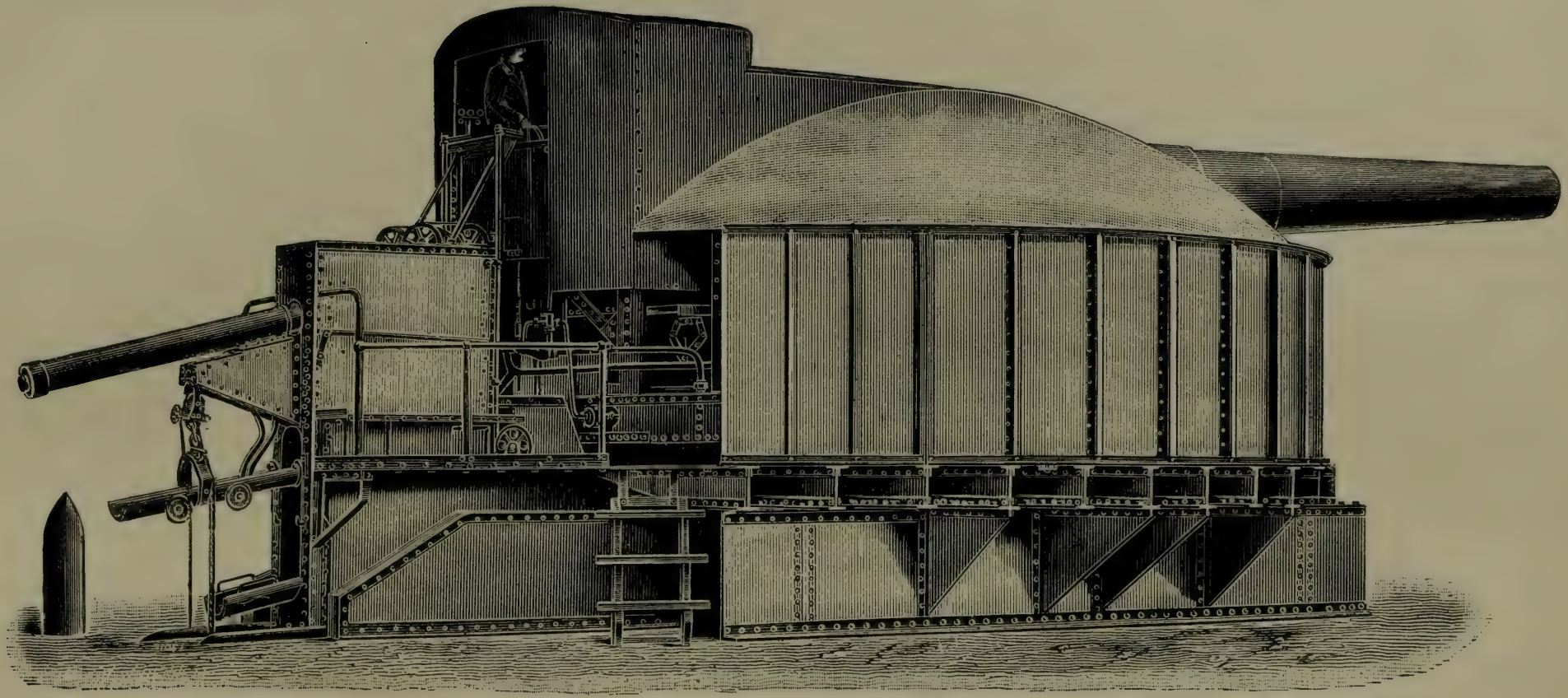
THE 28-CENTIMETER (11.02 INCH) GUN.

The gun exhibited is intended for coast defense and is 40 calibers in length. The leading particulars are:

Caliber	inches	11.02
Length:		
Complete	feet	36.75
Bore	do	33.99
Weight, complete	tons	42.67
Number of grooves		84

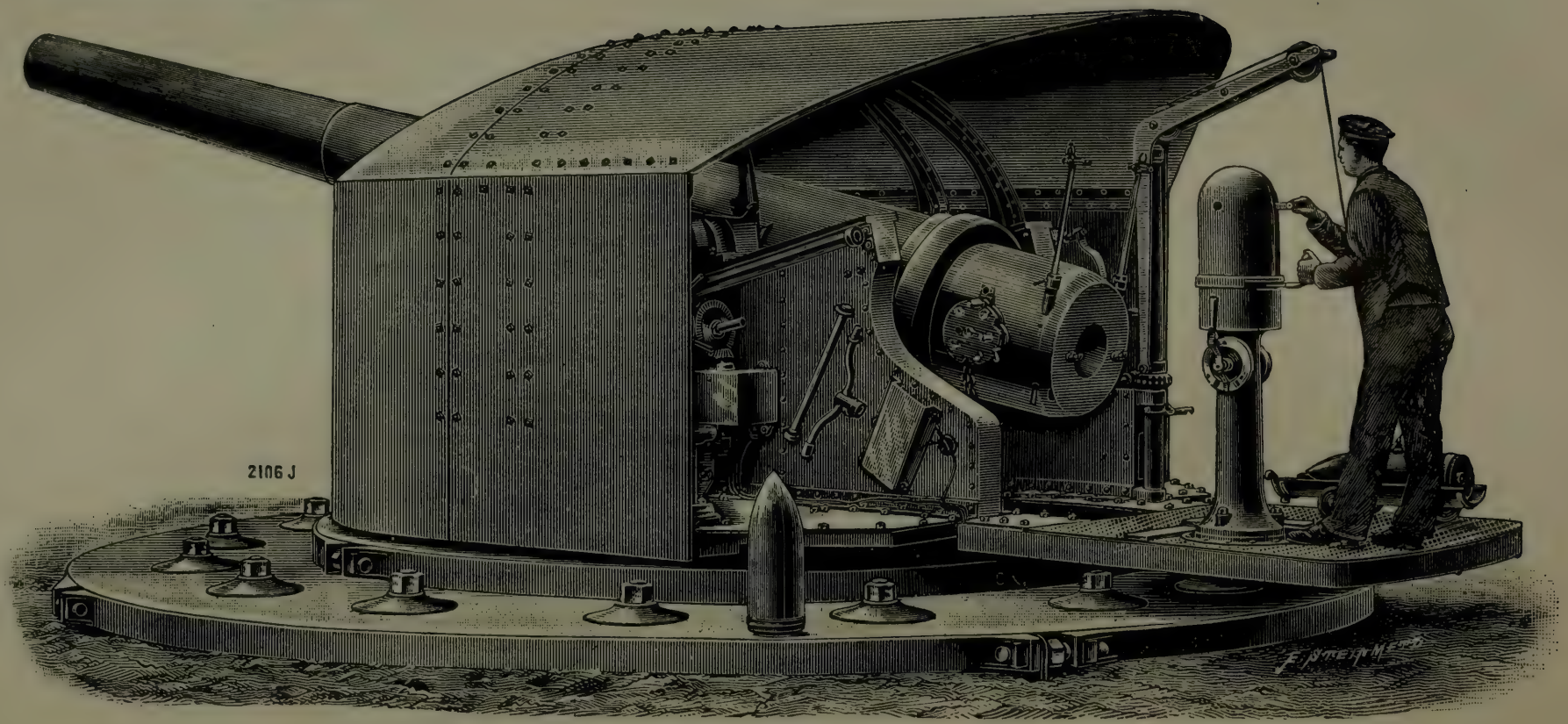
Experiments with this gun have given the following results:

Weight:		
Projectile	pounds	760.59
Charge (prismatic powder)	do	352.74



KRUPP 30.5-CENT. NAVAL GUN AND CARRIAGE.

Engineering.



KRUPP 21-CENT. NAVAL GUN AND CARRIAGE.

Engineering.

Initial velocity	foot seconds	2.067
Total muzzle energy	foot tons	22.536
Range at 45 degrees elevation	yards	22,200
Penetrating power of armor-piercing shell in wrought iron:		
At muzzle	inches	34
At 1,094 yards	do	30.74
At 2,187 yards	do	27.8

This gun, which was completed in 1892, is fitted with a vertically-rising breechblock.

The mount allows elevation from 45 degrees to minus 5 degrees, and is carried on a turntable resting on a number of steel balls. The lower portion is secured to the turntable, and its slides support the upper carriage.

Hydraulic power is used to obtain elevation, and the recoil cylinders are attached to the slides; the ends of the piston rods securing to projections on the under side of the upper carriage. The loading is also effected by hydraulic power, and this and the arrangement for working the breech mechanism is controlled from a platform on the turntable. A shield to protect the gun and mount is also carried by the turntable.

The mount weighs 59.05 tons and the shield 23.62 tons.

THE 24-CENTIMETER (9.45-INCH) GUN.

This is probably the most interesting gun of the series. It is 40 calibers in length and the breech mechanism is of the standard Krupp type. The following are some of the particulars:

Caliber	inches	9.45
Length:		
Gun	feet	31.5
Bore	do	29.15
Weight complete	tons	30.51
Number of grooves		56

The ammunition is similar in character to that for the other guns described. The weights of projectiles being 353 pounds and 474 pounds. The armor-piercing shell carries no bursting charge.

The powder charge is 254 pounds of prismatic or 92.7 pounds of smokeless powder, giving an initial velocity of about 2,500 feet per second.

During some firing trials, carried out in the presence of the German Emperor, at Meppen, April 28, 1892, the extraordinary range of 22,120 yards (12.5 miles) was obtained with this gun. The elevation was 44 degrees, the duration of flight 70 seconds, and the extreme height of the trajectory 21,456 feet.

THE 21-CENTIMETER (8.26-INCH) GUN.

This gun was mounted on a center-pivot naval carriage. Its length is 35 calibers. The mount consists of the upper carriage, the underframe and the turntable. The gun rests on its trunnions in the upper carriage, in the sides of which the recoil cylinders are formed, the

piston rods being attached to the forward end of the lower mounting. The turntable to which this latter is attached revolves on a center pivot and is supported on a live ring of steel balls. The gun can be trained and elevated by hand, but, besides the hand gearing, the mount is supplied with an electrical device for effecting all the necessary manipulations. An electric motor attached to the left side of the frame operates the elevating gear, while the motors for training and working the ammunition crane are on the right-hand side of the mount. Connected with the recoil press is a running-out brake by which the gun may be held in any desired position on the slides.

A shield of special steel 1 inch thick is attached to the turntable for the protection of the gun and carriage. The maximum elevation permitted by this mount is 25 degrees and the depression is 5 degrees.

The weight of the mount is 14.9 tons and that of the shield is 6.98 tons. The projectiles weigh 238.1 and 308.6 pounds, and as usual are of four kinds. Either brown prismatic, or smokeless powder may be used with this gun, the charges being 51.8 of the former with the 238-pound projectile, and 50.7 pounds of the latter with the 308.6-pound projectile. The maximum range in the latter case, with an elevation of 25 degrees, is 15,037 yards (8.54 miles).

THE 15-CENTIMETER (5.87-INCH) R. F. G.

Of the four calibers of rapid-firing guns exhibited, the largest was the 15-centimeter, which represented a caliber forming the principal armament of large cruisers and the secondary armament of battle ships. The gun was shown on a central-pivot naval mount consisting of the upper carriage (in the sides of which the two recoil cylinders were placed), a lower frame and a base plate, the two latter being separated by a live ring of steel balls. Rollers are fitted in the upper carriage, and, unless checked, the gun returns to firing position automatically. Elevation and training are effected by means of hand gearing.

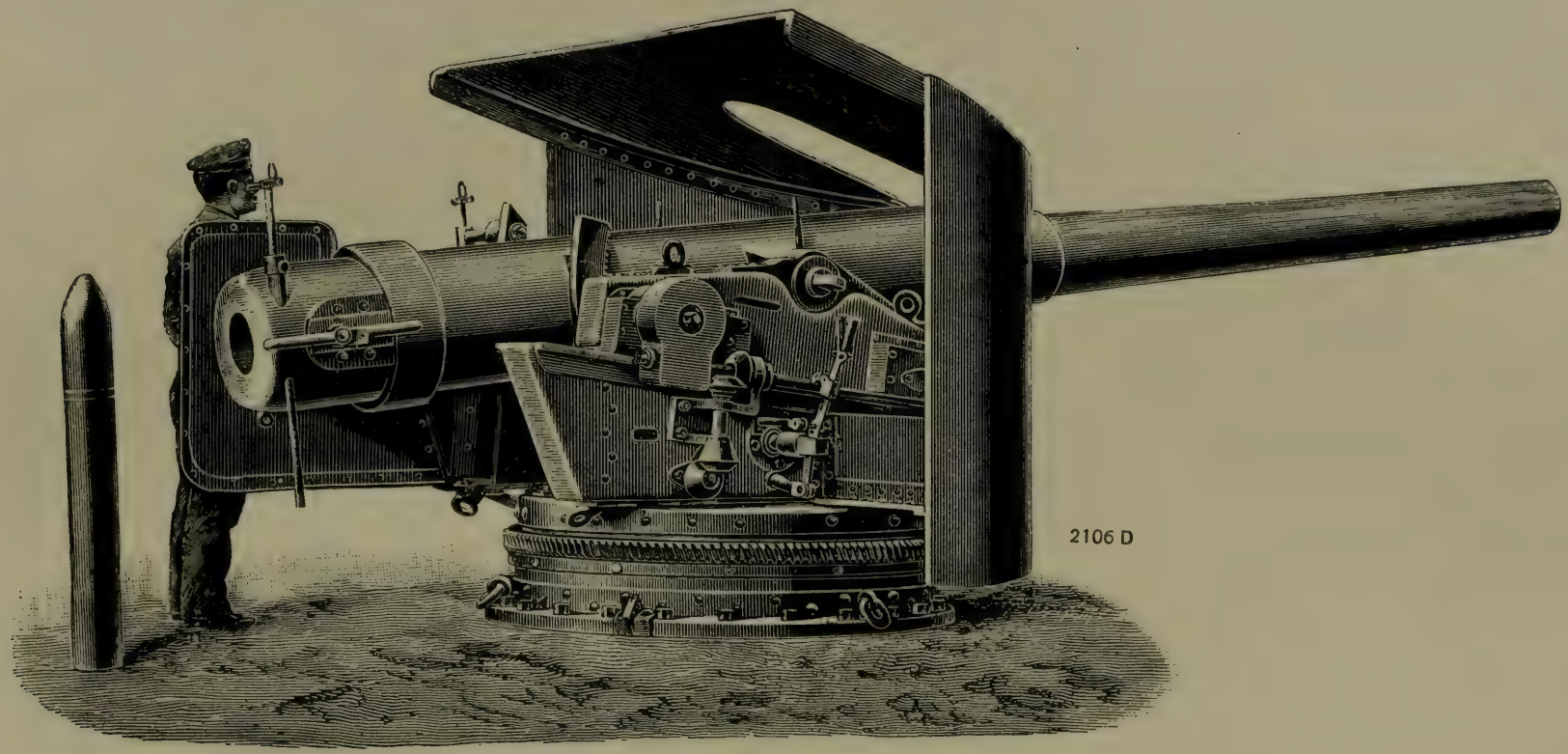
The following general particulars are given:

Caliber	inches	5.87
Length:		
Gun	feet	19.5
Gun, in calibers		40
Bore, in calibers		37
Weight, complete	tons	4.44

Four kinds of ammunition are supplied, and there are three different weights of each, viz: 76.05 pounds, 88.2 pounds, and 100.3 pounds. The lengths of the projectiles vary from 2.6 to 3.7 calibers. The powder used is the smokeless cube of the 1889 pattern.

Experiment has given the following data:

Weight:		
Shell	pounds	88.2
Charge	do	16.09
Initial velocity	feet per second	2,379
Total energy	foot-tons	3,456



KRUPP 15-CENTIMETER (5.9-INCH) R. F. GUN.

Engineering.

Perforating power of steel plate by armor-piercing shell:

At muzzle	inches	12.32
At 1,094 yards	do	9.80
At 2,187 yards	do	7.75

The gun exhibited was constructed in 1891, and had, up to the time of exhibition, been fired 269 times with full charges.

The following is an extract from the official statement of the experimental firing:

With respect to the speed of firing attained with the 15-centimeter (5.87-inch) rapid-firing gun, L '40, it should be noted that in shooting trials at the practice ground of the steel factory at Meppen, 55 shots, rapid fire, were delivered in series of 3, 4, 5, and 10 shots with good aiming in 396 seconds; this corresponds to a speed in firing of over 8 shots per minute.

A still more favorable result was obtained with a series of 18 shots, of which the first 8 shots were fired in 46 seconds at a target at 2,000 meters and immediately afterwards 8 shots in 40 seconds at 3,000 meters out into the open, and then again 2 shots at the aforesaid target, making in all 18 shots in 126 seconds.

Thus with aimed fire and two changes of range and target, 18 shots were delivered in succession at a speed of over 8 shots per minute. Without taking into consideration the alteration of range the speed of firing was 6 seconds for one shot; that is to say, 10 shots per minute.

Another series of 14 shots, of which the first 8 shots were fired in 48 seconds at a target 2,000 meters distant, then 5 shots in 22 seconds out into the open at 3,000 meters, and, finally, 1 shot at the aforesaid target took 93 seconds. This corresponds to a speed of firing of 9 shots per minute.

In this case also the speed of firing was 6 seconds for one shot; that is to say, 10 shots per minute, without taking the change of direction into consideration.

The hitting capability shown in these trials was very good, because of the 18 quick-fire shots that were delivered consecutively with a double change of target and range. All the 10 shots fired at the target at 2,000 meters were hits.

THE 12-CENTIMETER (4.72-INCH) R. F. G.

This gun was mounted on a central pivot naval carriage, similar to one which is shown in Pl. VIII, p. 110, General Information Series No. XI, and has the following particulars:

Caliber	inches	4.72
Length:		
In calibers		40
In feet		15.75
Of bore	calibers	37.7
Weight of gun	tons	2.08
Number of grooves		36

Three kinds of projectiles are fired, each being in three weights, 39.68, 44.1, and 52.35 pounds, the lengths varying from 2.6 to 3.7 times the diameter. A case shot weighing 52.35 pounds and one weighing 44.09 pounds is the fourth class of projectile made for this gun.

The following are some of the ballistic data connected with this gun:

Weight of projectile	pounds	39.68
Powder charge (smokeless)	do	8.37
Initial velocity	feet	2,585

Greatest range with elevation of 20 degrees	yards	10,608
Weight of projectile	pounds	44.09
Powder charge (smokeless)	do	7.93
Initial velocity	feet	2,412
Greatest range at elevation of 20 degrees	yards	10,116

The perforating power of the heaviest steel shell striking a wrought-iron plate, at the muzzle is 13.94 inches; at 1,094 yards it is 9.88 inches, and at 2,187 yards it is 6.84 inches. The rate of firing carefully aimed shots with this gun on the trial ground was 8 rounds in 35 seconds, corresponding to a firing speed of 13 rounds per minute.

The weight of the mount is 2.94 tons, and that of the shield, which is 0.98-inch thick, is 1.56 tons. The maximum elevation and depression permitted by the mount are, respectively, 20 degrees and 10 degrees.

THE 8.7-CENTIMETER (3.43-INCH) R. F. G.

This gun is also mounted on a central pivot naval carriage, and is chiefly intended for repelling torpedo-boat attacks. Excepting in size it closely resembles the 12-centimeter gun.

THE 7.5-CENTIMETER (2.95-INCH) R. F. G.

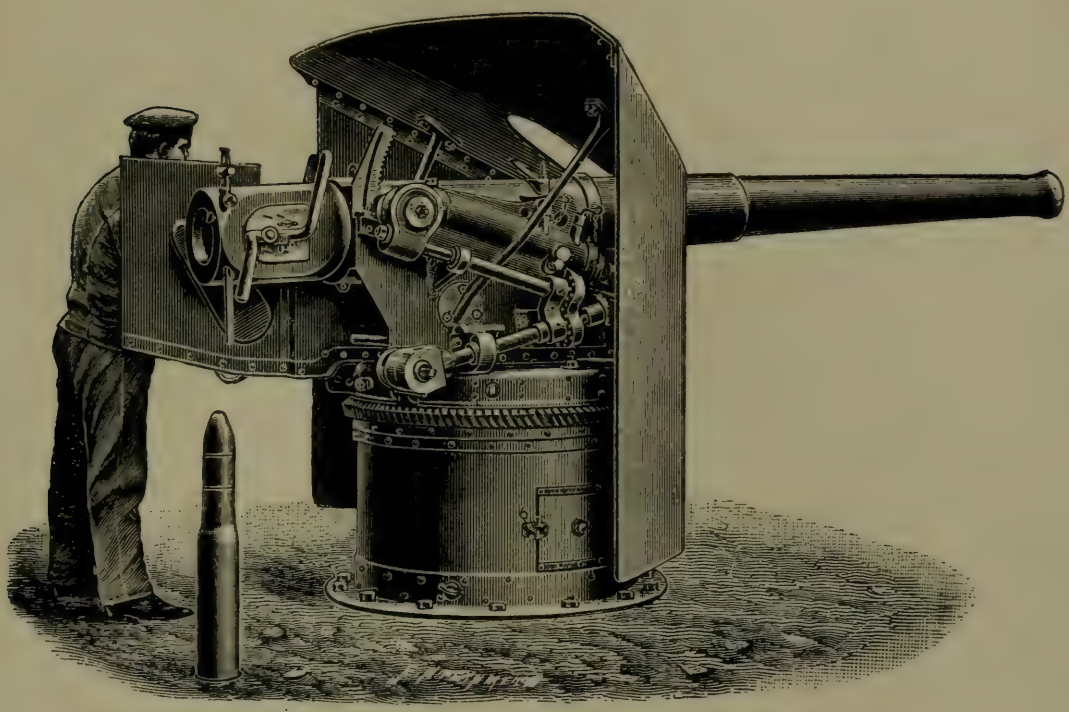
This weapon is specially designed as a flank gun for commanding ditches and trenches, and is shown mounted on a land mounting. It is short, being only 25 calibers in length, and has the following particulars:

Caliber	inches	2.95
Length	feet	6.2
Length of bore	calibers	22.3
Weight of gun	ton	.331
Number of grooves		28
Weight of loaded projectile	pounds	13.23
Powder charge (smokeless)	do	1.3
Initial velocity	foot seconds	1,640
Range at 8 degrees elevation	yards	4,156
Total weight of mounting and accessories	tons	1.64
Recoil	inches	7.87

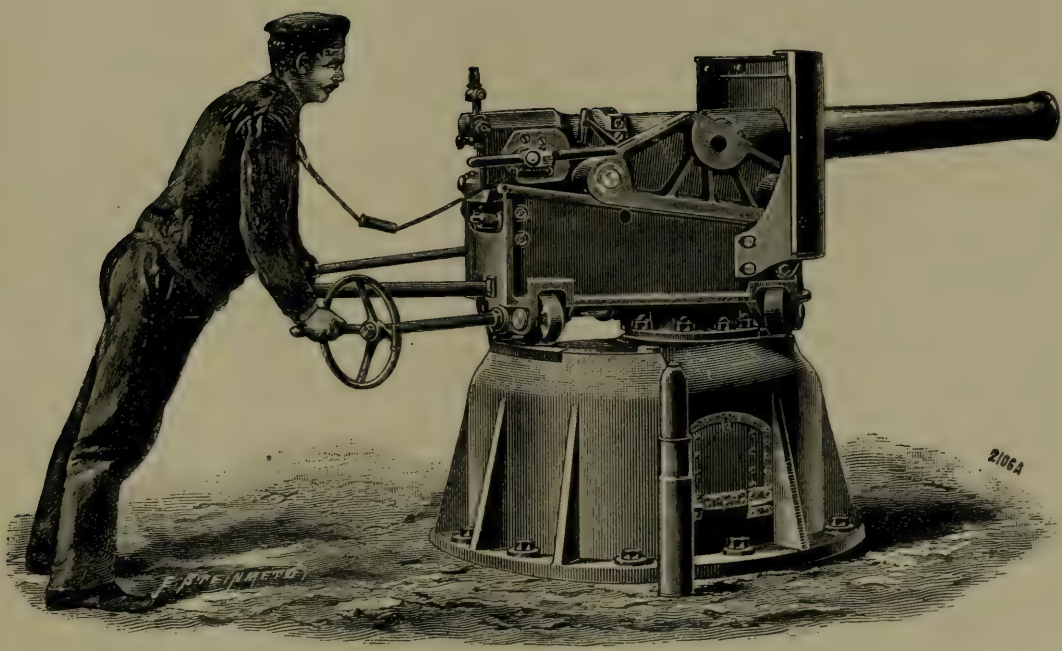
The projectiles supplied are cast-iron shell, shrapnel, and case shot.

Two types of field gun, both 2.95-inch caliber, one heavy and the other light, were exhibited. The following table contains their particulars:

		Heavy.	Light.
Caliber	inches	2.95	2.95
Length:			
Gun	do	82.68	70.87
Bore	calbers	25	24
Number of grooves		28	24
Weight, complete	pounds	683	518
Maximum elevation	degrees	20	20
Maximum depression	do	5	8

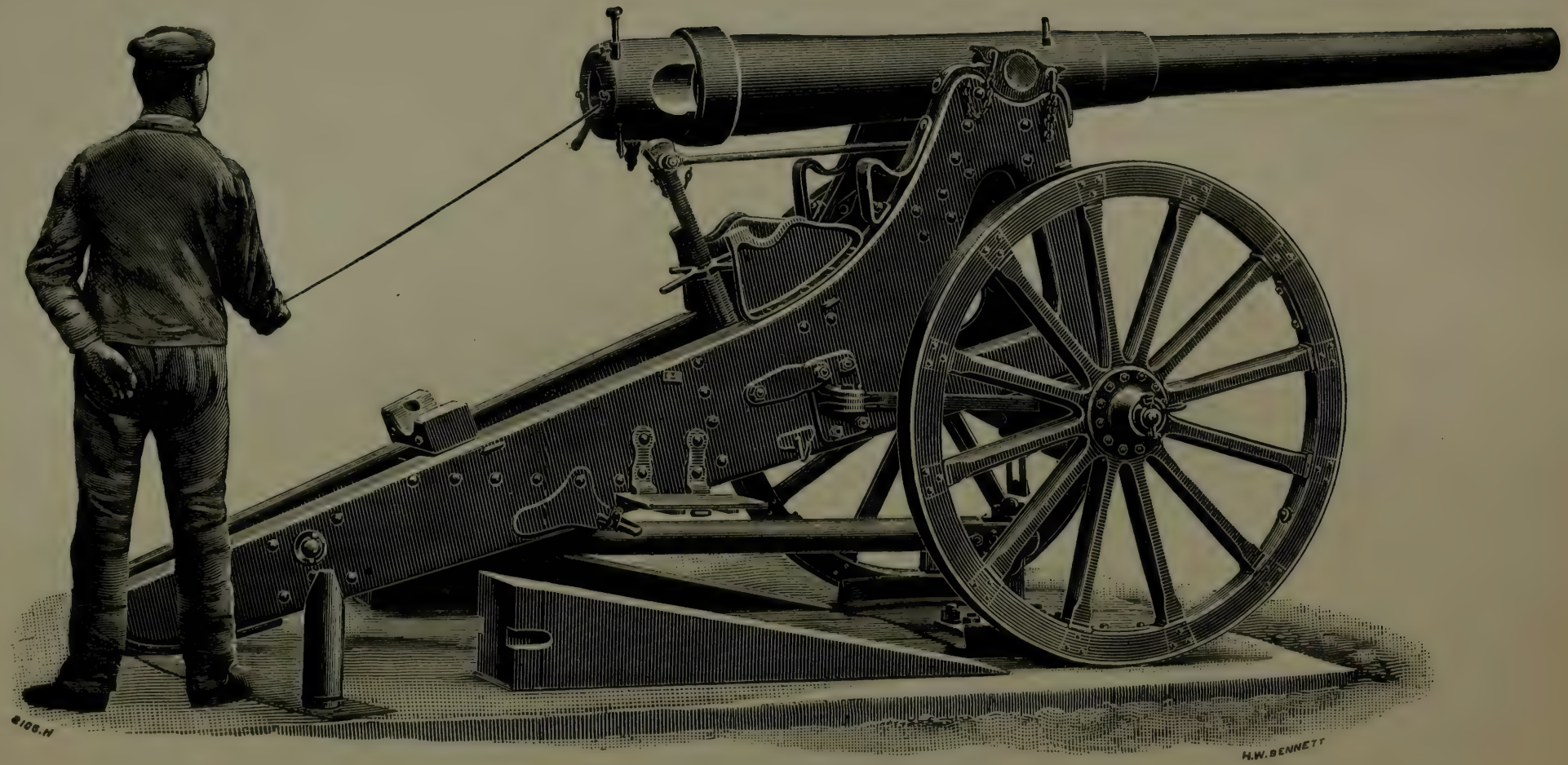


KRUPP 8.7-CENTIMETER (3.43-INCH) R. F. GUN.



KRUPP 7.5-CENTIMETER (2.95-INCH) R. F. GUN.

Engineering.



KRUPP 10.5-CENTIMETER (4.13-INCH) SIEGE GUN.

		Heavy.	Light.
Weight:			
Carriage	pounds	1,058	573
Empty limber	do	1,124	716.59
Equipment	do	101.4	66.14
Ammunition carried	do	515	293
Number of projectiles carried		36	26
Weight:			
Projectile	pounds	12.89	9.48
Powder charge (smokeless)	do	1.124	0.639
Initial velocity	foot seconds	1,640	1,394
Greatest range with 20 degrees elevation	yards	6,890	5,470

The heavy gun exhibited had fired 322 rounds.

SIEGE GUN, 4.13-INCH CALIBER.

One siege gun was exhibited of 4.13-inch caliber; it is 35 calibers in length, and is fired with a powder charge of 4.96 pounds. The following are some of the leading particulars of this gun, which is provided with the ordinary Krupp type of breech mechanism and a ring gas check. Five classes of projectiles are employed—cast-iron shell, steel shell, steel armor-piercing shell, shrapnel, and case shot. The weight of these projectiles is about 36 pounds.

The powder charges are: Prismatic powder, black, 8.8 pounds; brown, 10.36 pounds; smokeless powder, 1889 type, 4.96 pounds.

Ballistic data.

Charge.	Weight of projectile.	Initial velocity.	Maximum range, 35 degrees elevation.
	Pounds.	*Feet.*	*Yards.*
P. P. C/68, 8.8 pounds	35.27	1,591	.....
P. P. C/82, 10.36 pounds	35.27	1,886	11,260
W. P. C/89, 4.96 pounds	35.27	2,034	.....

Penetrating power of steel shell (35.27 pounds), with initial velocity of 1,886 feet.

Range.	Descending angle of trajectory.		Wrought-iron plate.	Steel plate.
	°	′	*Inches.*	*Inches.*
At muzzle	.....		9.84	7.09
At 1,093 yards	1	8	7.69	5.12
At 2,187 yards	3	3	5.12	3.94
At 3,200 yards	5	52	.....	.....

The leading dimensions of the gun and the carriage are:

Caliber	inches	4.13
Length:		
Gun	do	12.88
Bore	calibers	32.9
Number of grooves		32
Weight, complete	tons	1.156
Maximum elevation	degrees	35
Maximum depression	do	5
Weight of carriage and wheels	tons	1.417
Height of axis of gun from ground	feet	6
Width apart of wheels	inches	53.73
Weight of limber	ton	.374

The carriage is built of steel and is mounted on 2 wheels that are run in and out on a foundation track. This foundation is a heavy timber structure, and is arranged to allow lateral train of 45 degrees on each side. Inclines are placed in rear of the wheels to return the gun into firing position. The recoil is controlled by a hydraulic brake, the cylinder being pivoted to the foundation and the ram attached to the carriage near the trail.

SMALL GUNS FOR LAND SERVICE.

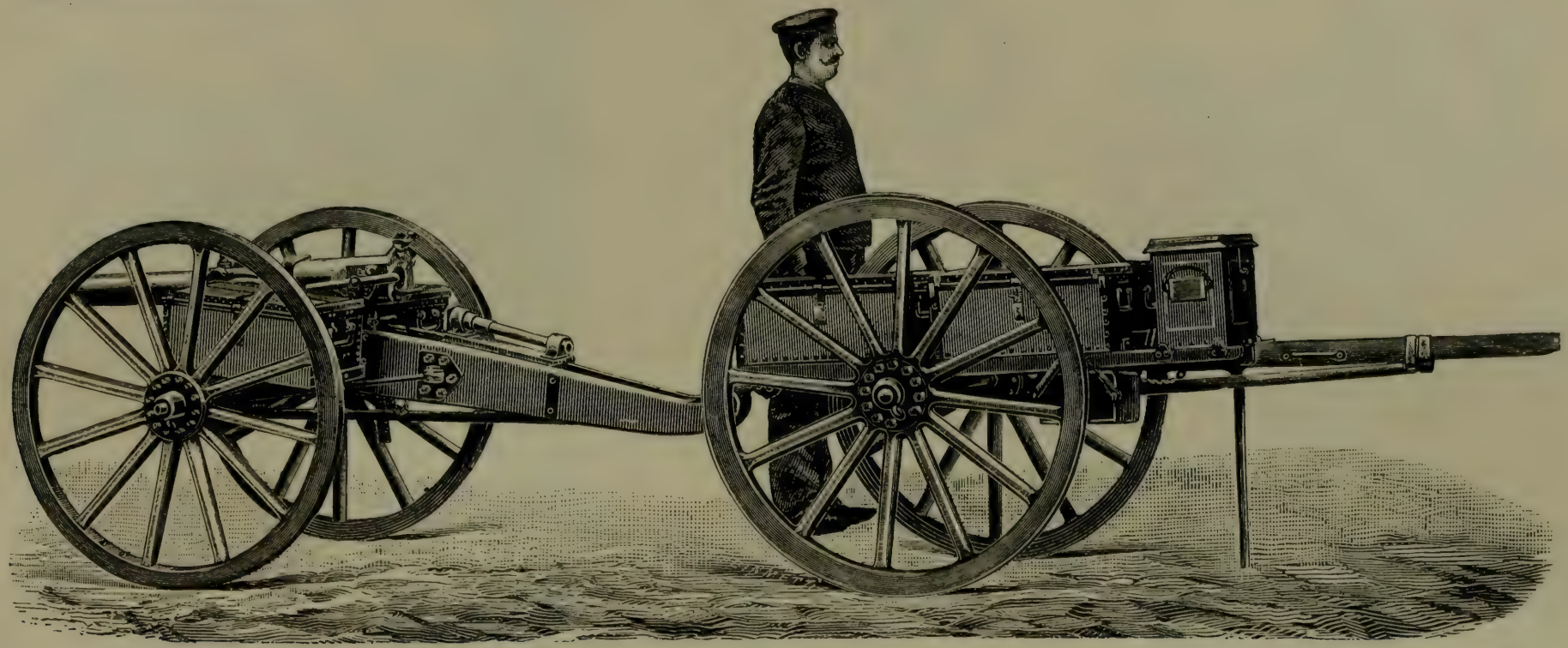
Four small guns completed the exhibit. These were a 2.4-inch landing and boat gun on boat mounting, and a steel-plate landing carriage; a 2.95-inch mountain gun and carriage; a 2.36-inch mountain gun and carriage arranged to be taken apart for convenient mule transport, and, finally, a 1.46-inch gun on a pivoted standard wheeled carriage for service in the bush.

The particulars of these four guns are as follows:

Data.		2.4-inch boat gun.	2.95-inch mountain gun.	2.36-inch mountain gun.	1.46-inch bush gun.
Caliber		2.4	2.95	2.36	1.46
Length:					
Complete	feet	4.1	3.28	3.18	4.6
Bore	do	3.78	2.88	2.76	1.4
Weight of gun, complete	pounds	232	220.5	198.4	88.2
Number of grooves		24	24	12	12
Projectile, weight	pounds	6.6	5.18	4.3	1
Charge:					
Coarse-grain powder	do	.88	.88	.44	.154
Smokeless	do	.3	.3	.....	.....
Range with 20 degrees elevation	yards	4,867	4,265	3,720	2,734

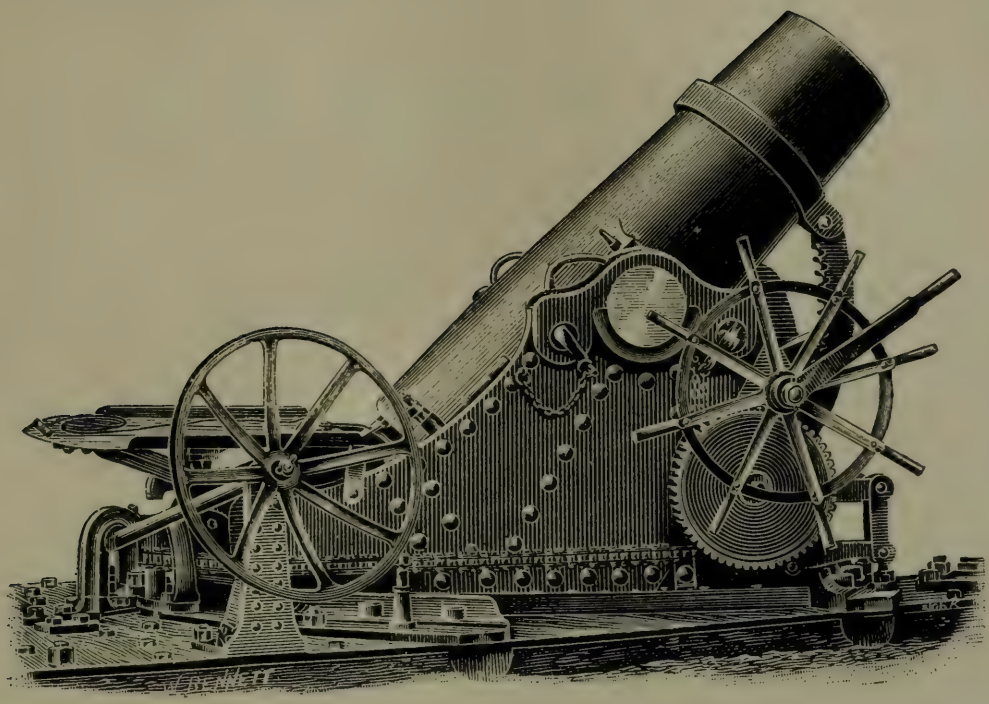
FORTRESS AND SIEGE MORTARS.

Three types of howitzers (4.72, 5.9, and 8.26 inch) and four types of mortars (5.9, 8.26, 9.45, and 11.02 inch) are manufactured at Essen. A mortar of 9.45-inch caliber was shown in the Krupp pavilion at Chicago. It is built up of a steel tube jacketed, and is provided with the sliding-



KRUPP 7 5-CENTIMETER (2.95-INCH) FIELD GUN.

Engineering.



KRUPP 24-CENTIMETER (9.45-INCH) MORTAR.

KRUPP 6-CENTIMETER (2.4-INCH) BOAT AND LANDING GUN.

Engineering.

block breech mechanism and ring gas check; elevation is obtained by a toothed sector attached to the gun, and operated by gearing on the mount.

The following are some particulars: Caliber, 9.45-inch; length, 59.85 inches (6.2 calibers); length of bore, 4.9 calibers; number of grooves, 28; weight of gun and breech, 1.72 tons. Three classes of ammunition are fired:

Projectiles.	Weight.	Bursting charge.
	Pounds.	*Pounds.*
Cast-iron shells	299.8	11.68
Steel shells	299.8	48.06
Steel shrapnel	299.8	2.99

With a powder charge of 11.9 pounds an initial velocity of 656 feet is given to the projectile, weighing about 300 pounds. The maximum range with an angle of 45 degrees is 1,401 yards. Under the foregoing conditions the effect of dropping a shell on moderately hard ground has been to produce a hole over 8 feet in depth and 19 feet 8 inches in diameter at the surface.

This mortar is mounted on a steel carriage turning on an iron plate pivoted by a central pin fastened to the heavy timber foundations; the carriage can be secured by clips to this plate. For transport a suitable wheeled carriage is provided.

Another interesting weapon of this class was a field mortar, 2.95-inch caliber, adapted for mountain and colonial service, and firing the same ammunition as the field gun. It can be carried by four men, and is easily mounted and dismounted.

The following are some principal particulars:

Gun:

Caliber	inches	2.95
Length	calibers	6.4
Length of bore	do	4.9
Number of grooves		12
Weight of gun	pounds	110.3

Projectiles.	Weight.	Bursting charge.
	Pounds.	*Pounds.*
Cast-iron shell	9.48	.22
Steel shell	14.33	.99
Mine shell	14.33	1.76
Steel shrapnel	9.48	.09

Weight of charge	pounds	.44
Initial velocity (with 9.48-pound shell)	feet	656
Initial velocity (with 14.33-pound shell)	do	524
Maximum range at 45 degrees elevation	yards	3,576

The mounting—carriage and foundation—resembles that of the heavier calibers; its weight is 106 pounds.

The following Krupp R. F. G. have been adopted for use in the German navy:

Calibers.		Length in calibers.	Weight of projectile.	Initial velocity.
Cm.	*In.*		*Pounds.*	*Foot seconds.*
15	5.9	35	76.1	2,329
10.5	4.13	35	26.5	2,329
8.7	3.43	30	19.84	2,130
5	1.97	40	3.86	2,231

The 15-centimeter gun is intended to fire also a 100-pound projectile with an initial velocity of 2,034 foot seconds, and the 10.5-centimeter gun a 35-pound projectile with a muzzle velocity of 2,034 foot seconds. The powder charges for these guns are 15.4 pounds and 5.21 pounds, respectively.

The mounts are central-pivot gravity-return carriages, and are said to be very satisfactory. One feature is a saddle, held by rod braces, for the use of the gun pointer. It is attached to the carriage and turns with it, permitting the man laying and firing the gun to keep his eye continually on the sights, while the elevating and training cranks are convenient to his hand. It is claimed that the 10.5-centimeter gun was fired 10 times in 15 seconds at Meppen.

NEW GRUSON R. F. G.

The gun proper is similar to the usual type of Gruson 57-millimeter (2.24-inch) gun, described in Pp. 399 to 401, No. VIII, but the breech closure is considered to be a great improvement over the one formerly used. It consists of six parts, including the block itself, has no springs to break or weaken, and is as simple as the latest type of Skoda gun, which is looked upon as one of the best extant.

There is a solid falling block, in which grooves are cut to receive the various parts, such as the lever, firing hammer, extractor, securing key, etc.

The lever is simple and has in its handle a small catch serving two purposes, the first for locking the block so that when loaded and it is desired to transport the gun the block can not, by any accident, come open, nor can the hammer, if pulled, strike the igniter and explode the cartridge; the second for use in removing the breechblock when the block has been lowered half way, and then the catch being set, the key tap can be removed, the lever withdrawn, and the block allowed to fall clear of the gun.

The firing hammer, which takes the place of the firing pin in other systems, has no circular or other springs, and is simply a hammer with two arms, one of which has a projection to strike the igniter, and the other a ring to which the lock string is attached.

The extractor is two-pronged, and works with great force as the lock falls, being pivoted back by the falling motion.

The key tap is on the left side of the lock, and is withdrawn as described above. A second tap, for the end of the lever, completes the list of parts.

The new block is solid and strong, and can be dismounted and assembled without the aid of any tools.

ITALY.

In the Italian budget for 1894–'95 are included the following appropriations for guns, torpedoes, etc., inclusive of construction and repair of armaments, 12,988,799 lira ($2,505,834.29).

The 120-millimeter (4.72-inch) R. F. guns of the *Re Umberto* have a novel mounting. They are arranged in half turrets about 4.72 inches thick, which project beyond the ship's side. These turrets, or shields, are pivoted at top and bottom, the vertical line through the pivots passing through the center of gravity of the shield, and thus rendering it possible to train them readily by hand, notwithstanding their weight. Gearing for training has also been supplied. Steel traverses are arranged inside the turret for further protection against high explosive projectiles, and other traverses are to be placed between the guns on the battery deck.

The sights for these guns are arranged very much like the "bar and drum" sights designed in England, and similar sights will hereafter be fitted to all the 120-millimeter (4.72-inch) and 152-millimeter (5.98-inch) R. F. G. mounts.

After having had competitive trials between Krupp and Terni projectiles for the 152-millimeter guns, the Government has decided to manufacture all armor-piercing shell for this caliber at the Terni steel works, and preparations are in progress to turn out projectiles for heavier guns in the near future. A secret tempering process is used.

According to London Broad Arrow, the Italians have recently condemned 500 field guns on account of the erosive action of the smokeless powder used.

A 21-centimeter (8.27-inch) rifled mortar has been adopted by Italy, intended to throw the same shell as the 21-centimeter howitzer. It is 3 calibers long, weighs 212 pounds, and has a bursting charge of 42 pounds of wet gun cotton in disks. There is also a shrapnel of the same weight containing 900 balls, each about 8 ounces in weight and having a bursting charge of 2.4 ounces. Several charges are supplied for this weapon, the largest of which is 15.5 pounds of progressif-pulver No. 1.

A 37-millimeter (1.46-inch) R. F. G., loaded with 1.1 ounces of ballistite, exploded at the marine arsenal at Venice, in September, 1892, owing to the bursting of the shell in the bore.

RUSSIA.

The Russian navy budget for 1894–'95 contains a total appropriation for guns, torpedoes, and electric lighting of 5,725,791 rubles ($2,129,784.25).

The following type guns have been adopted for future naval armaments: 12-inch L/40; 10-inch, 8-inch, 6-inch, R. F. and 4.72-inch R. F. G. of 45 calibers length; 2.56, 1.85, and 1.46 inch R. F. G. and 1.46-inch R. C. for auxiliary batteries. The Krupp breech closure has been discarded. and one which is essentially French in principle has been adopted. The 12-inch gun mentioned above is intended to replace the 12-inch Russian Krupp guns 35 calibers in length which the Russians have been using for some years. It is a more powerful gun, and is designed to have an initial velocity of 2,600 foot seconds with smokeless powder. Two of these guns have been sent to Sebastopol from the Aboukoff factories. The design is that of Col. Brynck, formerly a lieutenant in the navy. The 6 and 4.72 inch R. F. G. which have been adopted have Canet mounts. The smaller R. F. G. are on the design of the Hotchkiss guns.

TORPEDOES.

Almost all modern war vessels are now fitted to carry and use automobile torpedoes. Although many of the existing discharge tubes are capable of training through a considerable arc, it is considered preferable that future tubes carried by ships should be fixed. Discharge tubes are more advantageously situated when they are below the water line, but great difficulties have been experienced in launching the torpedoes in a satisfactory manner from these submerged tubes when the vessel is steaming at high speed.

The velocity of ejection depends upon the mean pressure employed, and this is necessarily limited to about 40 pounds per square inch, as the torpedoes are lightly built and unable to withstand a great pressure from without.

Compressed air is being superseded by gunpowder or some other explosive, as a propellant for torpedo discharge.

Ranges have been somewhat increased during the past year.

There appears to be a general tendency to discredit the use of nets, on account of their hindrance to manœuvring and the efficiency attained by the net cutters.

The 45-centimeter (17.72-inch) by 5-meter (16.4-feet) torpedo seems to be the most popular size in all foreign navies.

AUSTRIA.

No under-water discharging apparatus has yet been adopted in the Austrian vessels. Powder discharge is preferred to compressed-air discharge for launching torpedoes. The powder used is a large-grained black powder of the usual composition, the cartridge being located in the breech closure, and an ordinary friction primer is employed to ignite the charge. The charge for the 45-centimeter (17.72-inch) torpedo ranges from 4.5 to 5.4 ounces, which corresponds to pressures of 17.6 to 24.5 pounds per square inch, and velocities of discharge of 29 to 45.9 foot seconds. Higher velocities are never used in service, although sometimes employed for purposes of comparison. The usual angle of entry into the water is about 13 degrees.

Torpedo nets are carried only by vessels exceeding 5,000 tons displacement. The booms are about 27 feet long, and the heels are from 4 to 4½ feet above the water line.

ENGLAND.

The present practice in the British navy is to fit both over-water and submerged discharging apparatus to the latest vessels. Of the 7 tubes in the *Royal Sovereign*, 2 are under-water tubes set with a permanent angle of depression. The manufacture of the under-water tubes is being pushed with all dispatch at the Portsmouth factory. The 18-inch Whitehead torpedo has been adopted, and all the older patterns are to be replaced immediately.

Some important experiments conducted at Portsmouth for the purpose of comparing gunpowder and cordite for discharging torpedoes resulted in a victory for the latter. The use of cordite is said to overcome the offensive fouling produced by gunpowder, besides being practically smokeless. A small quick-burning cordite is found to give the best results. Recent experiments at Elswick with cordite resulted in exceedingly regular velocities and pressures. With a 14-inch Whitehead torpedo 2.5 ounces of cordite gave a pressure of 35 pounds per square inch and a mean velocity of 39 foot seconds, and with an 18-inch torpedo 4 ounces of cordite gave a mean velocity of 42 foot seconds with an average pressure of 32 pounds per square inch.

Off Catania, while the Mediterranean fleet was engaged in torpedo practice, the *Nile* lost a torpedo, which sank as soon as it left the tube, and was not recovered.

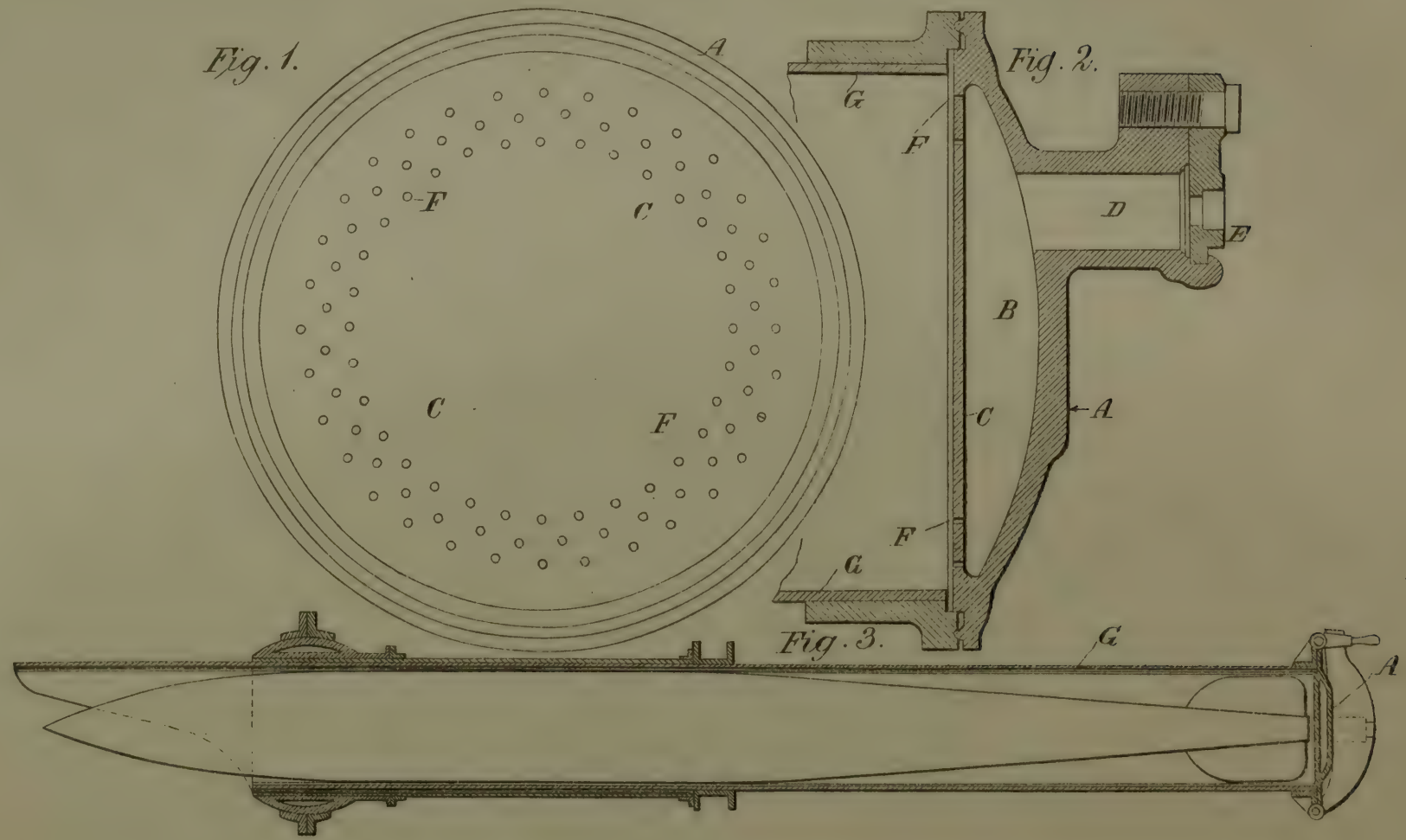
On August 16, 1892, the *Royal Sovereign* had torpedo target practice with the two under-water broadside tubes and the five above-water tubes, all fixed tubes. The target was three buoys, representing a vessel 300 feet in length. The ship was steaming at from 11 to 12 knots speed. All three starboard torpedoes were fired at about 600 yards distance, the practice being fair. The torpedoes were all recovered and recharged, after which they were fired from the port tubes, at a slightly greater distance. The practice was not very good from the over-water tubes, but fairly good from the submerged tube. The stem torpedo was discharged too soon, and the result was very poor.

During manœuvres the torpedoes supplied to torpedo boats are to have thin copper heads, filled with water, which will telescope on impact, in order to determine if a torpedo hits. A Holmes light arranged to burn on reaching the surface will also be fitted to the rear end of each torpedo to facilitate its recovery.

According to Broad Arrow, the submerged tubes for 18-inch torpedoes, manufactured at the Portsmouth factory, are of gun metal and brass, and weigh with the guide bars about 9 tons. The time required to make a pair of tubes is two months, and the cost from $9,732 to $14,598 per pair. Messrs. E. W. Lloyd and C. W. Hutchinson, of the Elswick Works, have invented certain improvements in the mechanism of the

FIRING A TORPEDO WITH CORDITE CHARGE

[This Drawing is a reproduction of the Original on a reduced scale.]



discharge tubes which are described in the patent specification as follows:

For launching torpedoes from torpedo launching tubes we provide at the rear end of the tube, either in the door or other part, an explosion chamber, into which the gases arising from the explosion of an impulse charge of explosive are first received and from which they pass into the torpedo launching tube through orifices so restricted as to prevent the escape of unconsumed portions of the explosive and to sufficiently retard the escape of gas to produce such pressure in the chamber as will insure the speedy and uniform combustion of the explosive, and to admit the gas into the launching tube at so moderate a pressure as to be uninjurious to the torpedo.

The apparatus may consist of a hollow door hinged to the rear end of the launching tube and having formed on it, to the rear, a small chamber to receive a metallic cartridge case containing the impulse charge of explosive, such chamber opening into the larger chamber formed by the hollow interior of the door and a passage or passages being formed through the front of the door through which the unconsumed charge can not be blown, but through which the products of explosion must pass from the chamber into the launching tube.

The passage through which the gas flows from the chamber to the launching tube or gun may consist of a large number of small holes, or may consist of a small number of larger holes, or of a hole, suitably arranged, any or all of which may have an adjustable or a fixed area of opening.

The cartridge chamber and the combustion chamber may be otherwise formed, and otherwise attached to the launching tube.

Fig. 1 shows the inner face of a torpedo tube door A, and fig. 2 is a section of the same.

Fig. 3 shows a longitudinal section of the tube and door to a smaller scale.

The door A is hollowed in shape as to form a combustion chamber B closed by the perforated plate C.

The cartridge or charge of explosive is placed in the smaller chamber D, and is held there by the hinged door E.

When the charge is ignited, the products of combustion pass into the chamber B, from whence the gases pass through the holes F in the plate C into the tube G.

The form of the passages for the escape of gas from the chamber B into the tube prevents the escape of the explosive otherwise than in the form of gas, or in such small particles as will instantly be gasified. The restriction of the area of passage causes a considerable gas pressure and consequent high temperature of explosion and combustion in the chamber B, and then admits the gas at a sufficiently reduced pressure into the launching tube.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is—

1. The combination of a launching tube, a chamber or chambers to receive an explosive, and an opening or openings from the chamber or chambers to the rear of the tube so restricted in size that the pressure in the chamber or chambers shall be materially greater than that in the tube.

2. The combination of a launching tube, a hollow door at the rear of the same, and an opening or openings leading from the hollow of the door to the tube so restricted in size that the pressure in the hollow shall be materially greater than that in the tube.

3. The combination of a launching tube, a hollow door at the rear of the same, an opening or openings leading from the hollow of the door to the tube so restricted in size that the pressure in the hollow shall be materially greater than that in the tube, and a cartridge chamber opening at one end into the hollow door and closed at the other end by a door.

Whitehead's new torpedo factory near Weymouth is said to be capable of turning out about one hundred 18-inch torpedoes a year, and a considerable extension of the plant is contemplated, in case the orders received justify an increase in the output. Unlike the Woolwich factory, the firm make their own engines and all parts of the torpedoes excepting the steel castings for air vessels. According to Mr. Whitehead, the air flasks made for the British navy are subjected to an oil test pressure of 115.5 atmospheres (1,697 pounds per square inch). The usual Schwartzkoppf test is 130 atmospheres (1,911 pounds per square inch). The admiralty are having experiments made with aluminium, with a view of using it as a substitute for brass in the construction of torpedo discharge tubes and fittings.

FRANCE.

In addition to purchasing torpedoes from Mr. Whitehead at Fiume, the French Government has established a factory of its own in the Toulon arsenal, for the purpose of eventually becoming independent of foreign sources for its torpedo supply. The establishment consists of three departments: The factory, the repair shops, and the torpedo regulating and testing department.

The factory is well equipped with machinery and trained mechanics, and has a capacity for producing about 100 torpedoes annually. Important repairs are made in the repair shops, while minor repairs, overhauling, and inspection are attended to in the regulating establishment. When torpedoes are ready for service they are delivered to the regulating department and undergo trial, after which, if accepted, the final adjustment and regulating is effected and they are placed in store, ready for issue to the service. The cost of the torpedoes made at Toulon is said to be from $1,500 to $2,000 each, according to size.

The six standard sizes of torpedoes adopted in the French navy are as follows:

Diameter.	Length.
45^{cm} (17″.72)	5^{m} (16′.4)
45^{cm}	4.17^{m} (13′.68)
381^{mm} (15″)	5.75^{m} (18′.86)
381^{mm} (15″)	5^{m} (16′.4)
356^{mm} (14″)	5^{m} (16′.4)
356^{mm} (14″)	4.75^{m} (15′.58)

The air cylinders of the 381-millimeter and 356-millimeter torpedos are charged to a pressure of 1,200 pounds per square inch, and those of the 45-centimeter weapon to 1,280 pounds per square inch. The torpedo discharge tubes are usually of the above-water spoon type arranged to train. Fixed tubes without spoons are fitted in the stems of torpedo boats. Both steel and composition tubes are in service.

Submerged tubes are being installed in some of the new battle ships, and are on the same general principle as those adopted for the British navy. They are manufactured by M. Canet.

The Canet over-water tubes for powder discharge are described on p. 197, No. VIII. Since then some modifications have been made in the mechanism in order to combine the electrical control with the advantages of the mechanical firing attachment, which is believed to be more reliable in action and less liable to miss fires than the electrical firing arrangement. The percussion primer has been retained, and electricity is only utilized for releasing the torpedo and firing bolt.

While M. Canet fits his discharge tubes with electrical as well as mechanical firing apparatus, and also the combination above described, the usual practice in the French navy is to employ only mechanical apparatus for torpedo discharge.

An ingenious arrangement has been adopted to hold the torpedo in the tube until it is to be discharged, and its operation is as follows: A steel cylinder about 4 inches deep and 6 inches in diamter is fitted underneath the rear end of the tube, and a bolt passes through the top of the cylinder and is attached to a composition piston working in the cylinder. There is a spiral spring underneath the piston, which acts to keep it pressed upward and causes the bolt to engage in a socket in the torpedo shell. The pressure of the powder gases is admitted to the piston through the top of the cylinder, and, as soon as the charge is fired, the pressure forces the piston and bolt down, and leaves the torpedo free to move under the increasing pressure of the gases. The large area of the piston causes it to move soon enough to release the torpedo while the pressure in the tube is still very small.

The powder charge used in the French service for discharging torpedoes is made into a disk-shaped cartridge and is placed in a small chamber in the breech door. In front of this, a circular screen diffuses the gas upon the circumference of the torpedo and prevents bringing too much pressure on the mechanism of the tail. The dimensions of the cartridge vary with the size of the charge and the type of cartridge-holder. In general it is from 4 to 6 inches in diameter and from half an inch to an inch in thickness. The cartridge bag used is of coarse, brown serge, and is stitched through with twine to hold the powder in place and to stiffen the bag. The primer used is a percussion primer, and the flame communicates with the center of the cartridge by means of a channel arranged for that purpose.

The torpedo is discharged with a velocity of about 39 to 40 foot seconds and a mean pressure of from 29 to 44 pounds per square inch, the initial pressure being somewhat higher. No gas check is used upon the torpedo.

The weight of powder charge varies with the different sizes of torpedoes and with different discharge tubes and installations. With Canet tubes the charge for the 38-centimeter (14.96-inch) by 5-meter (16.4-feet)

torpedo is 4.4 ounces, and that for the 45-centimeter (17.72-inch) by 4.17-meter (13.7-feet) torpedo is 5.3 ounces. The powder used is a special powder with grains 8 by 11 millimeters (0.31 by 0.43 inches).

The short 45-centimeter torpedoes did not perform satisfactorily at first, but since reducing the powder charge much better results are obtained.

When air is used for discharge the accumulators are charged to about 1,800 pounds pressure per square inch. The flasks for the 45-centimeter torpedoes are charged to a pressure of about 1,300 pounds per square inch, and those of the smaller torpedoes to about 1,000 pounds per square inch.

The usual allowance of torpedoes is 2 for each tube and 2 others in reserve. On board the torpedo boats 2 men are allowed per tube, one to point and one to fire. In the larger vessels the number of men to each tube varies somewhat. On board the battle ships 2 men are assigned to each tube, and 6 are detailed to transport the torpedo from the torpedo room to the tube. On board the small cruisers 4 men are assigned to the 2 bow tubes, situated nearly side by side, and 4 others to each of the remaining tubes. Overhead rails are fitted, whenever practicable, for use in transporting the torpedoes.

The engines of all torpedoes on board ship are turned by hand every day and once each week by compressed air, of which a pressure is left in the air magazine for the purpose. At longer intervals the entire mechanism is tested.

Copper exercise heads are now supplied for practice, and are said to work very well, and to absorb the shock when the torpedo strikes.

In clearing for action the vessel's torpedo tubes are always loaded. In torpedo boats, the tubes are kept loaded at all times.

The latest French battle ships have hollow iron booms, about half an inch thick, and of the following approximate outside diameters: At the ends 6.5 inches, and at mid length 11 inches. The booms are about 26 feet in length, and the heels are secured from 2 to 4.5 feet above the water line, or immediately above the armor belt. The net when rigged out is about 24 feet from the ship's side. There are usually 10 booms, each side, spaced about 34 feet apart, supported by lifts attached to the hull about 8 feet above the heels, and a little forward of them, so that when the booms are rigged in and aft the ends are raised into their places alongside. The nets brail up to a wire ridge rope by 4 brails, between each pair of booms, the trails leading along and from the booms. When rigged in, the ends of the booms point up and aft, and a furling line is passed round the nets and through ringbolts or over a wire jackstay on the ship's side. The ridge rope is made fast to each boom so that they all work together. The net is rigged out by the swinging boom, which is about 50 feet long and is located about 100 feet from the bow and 18 feet above the water line. When alongside, the booms raise the upper edge of the net about 10 feet above the water.

Brailing reduces the depth of the net to less than 4 feet, and the furling gaskets further reduce this to about 18 inches.

The brails are of 1-inch steel wire rope, and the guys of 2½-inch steel wire, leading from bands on the boom ends to the side, about 5½ feet above the water line. The spread is about 12 feet, and the after guy is of fixed length, while the forward one has a small tackle to set it up taut. When alongside the ends of the booms rest in crutches.

In the low-ended vessels the booms are very much shorter, and the nets do not extend beyond the superstructure where the sides are sufficiently high to support the lifts. Bow and stern nets are no longer used, and all nets are losing in favor, in view of the general inconvenience attending their use and the efficiency of the net cutters.

GERMANY.

The Germans have established two naval torpedo boards at Kiel; one on torpedo attack and the other on torpedo defense. The board on attack is devoting its attention chiefly to the improvement of net cutters, and that on defense to the strengthening of nets. The defense is said to be ahead at present, as the weight of the net has been increased and the torpedoes do not penetrate.

The torpedo vessel *Greif* is engaged in carrying out experiments with a 45-centimeter (17.72-inch) torpedo under-water discharging apparatus, which, if satisfactory, will be fitted to the *Kaiserin Augusta* and other vessels. The German torpedo officers are said to prefer powder discharge to that by compressed air. The powder used in the German service is the special powder adopted by Schwartzkopf, the composition of which is kept secret. The location of the charge in the tubes is in the breech closure a little to the right of the center. A friction primer is used for firing.

The latest model (1893) Schwartzkopf torpedo is of the following dimensions: Forty-five centimeters (17.72 inches) by 13.35 feet; weight, 983 pounds; weight of charge, 198.4 pounds. Air flask, 43.3 inches long by 17.72 inches diameter and having a capacity of 35.3 gallons.

HOLLAND.

Some torpedo tubes recently furnished to the Dutch navy by Mr. Whitehead have a sliding spoon intended for discharging torpedoes of different lengths from the same tube. The spoon travels to and fro in the tubes, motion being given by means of a rack on top of the spoon and a pinion on the upper part of the tube, and working in a small hole through it. The guide slot in the spoon is shaped as usual, and is continued to the rear of the tube by means of followers (of various lengths, according to the length of the torpedo) which are pushed in from the rear of the tube until they abut against the rear of the spoon.

ITALY.

Both the Whitehead and Schwartzkopf torpedoes are used in the Italian service, and the latter company has already supplied them with about 900 torpedoes.

The weight of the 45-centimeter (17.72-inch) by 5-meter (16.4-foot) Schwartzkopf, of the pattern selected by Italy, is 1,197.1 pounds, and the weight of charge carried was at first fixed at 110 kilos (242.5 pounds). After experimenting, however, it was decided that this charge was needlessly large, and it is intended to reduce it somewhat, and to utilize the space thereby saved to increase the length of the air flask in order to get greater speed.

Some recent trial runs gave the following data:

Distance.		Speed.	Pressure in flask.
Meters.	*Feet.*	*Knots.*	*Pounds.*
400	1,312	30.8	367.5
600	1,968	26.1	132.3
800	2,625	25.9	88.2

The powder charges used in the tubes are: For the 356-millimeter (14-inch) torpedoes 4.4 ounces; and for the 45-centimeter (17.72-inch) torpedoes, 6.1 ounces.

The oil test for air flasks required by Italy is 135 atmospheres (1,985 pounds).

Unless in armored vessels, torpedoes are hereafter to be launched either from the spar deck or from under water, to avoid all danger of explosion between decks. Under-water tubes seem to have the preference. For discharge by compressed air, a pressure of 4 atmospheres is obtained and 1.5 to 2 atmospheres used for discharge.

The Italians have abandoned the use of ballistite, on account of the uncertain pressures obtained and of the corroding effects of this explosive. In future compressed black powder is to be made use of.

RUSSIA.

The Russian automobile torpedoes are Whiteheads, but are manufactured in Russia. From time to time new model torpedoes are purchased from Mr. Whitehead, and copies are made in the Russian factories. There are two factories—one in the Government works at Aboukoff, and the other in the Loesner works at St. Petersburg. The capacity of each is about 50 torpedoes annually. All torpedoes are fitted with copper war heads. The exercise heads are of steel.

Torpedo discharge is by compressed air or by powder, and all tubes are fitted with both systems. The air pressure employed is said to be exceedingly low.

There are two torpedo depots in the Black Sea, one at Nikolaief and the other at Sevastopol. They are equipped with shops for repairing, testing, and adjusting torpedoes, with suitable trial waters at hand. No torpedoes are manufactured in these establishments.

The new model 45-centimeter by 6-meter Whitehead carries 360 pounds gun-cotton charge, and is credited with a speed of 30 knots at 400 yards' range.

While the allowance of torpedoes varies somewhat, it is usually about 3 torpedoes to each tube.

All torpedo discharge is above water. Russian officers do not favor the use of nets.

ARMOR.

The superiority of the Harvey process of surface hardening armor plates having been conclusively demonstrated, it has been adopted by nearly all the leading manufacturers of armor.

AUSTRIA.

A series of important armor-plate trials was carried out in the autumn of 1893, at Pola, Austria, to determine the armor to be employed for three new coast defense vessels under construction for the Imperial navy. The competing firms were Messrs. Cammell & Co. and Vickers & Co., of England; Messrs. Krupp and the Rhenish Dillingen Company, from Germany, and the Austrian firm of Witkowitz & Co. The dimensions of the plates were fixed at 7 by 6 feet by 10.8 inches, and they were secured to a 20-inch wood backing by six 4.3-inch bolts. Messrs. Vickers, Cammell, and Witkowitz sent homogeneous nickel-steel plates, and Vickers & Co., in addition, also sent a Harveyed steel plate, while the plate furnished by Herr Krupp was of Harveyed nickel steel. Each plate was subjected to 5 shots, one at each corner from a 15-centimeter (5.9-inch) gun, with a projectile weighing 112.4 pounds, and a charge of 39 pounds of prismatic powder, giving a striking velocity of 1,980 foot seconds, and a fifth shot was fired at the center from a 24-centimeter (9.45-inch) gun, the steel projectile weighing 474 pounds, and the charge 99 pounds, giving a striking velocity of 1,417 foot seconds.

The nickel-steel plate furnished by the Dillingen firm was the first one tested. The first projectile, a Streiteben shell, penetrated the plate, and remained uninjured with the point projecting 5.9 inches beyond the rear surface of the plate. At the point of impact the edges of the orifice were raised 1.38 inches, while through a diameter of about 17 inches the rear surface was broken and bulged out some 2.56 inches. The second projectile, a Krupp shell, went clear through plate and backing, and only a fragment was afterwards found in rear of the target. The edges at point of impact were raised 1.77 inches, and in rear the plate was broken and bulged outwards about 4 inches through a diameter of about 17 inches. The third projectile (Streiteben) penetrated 8.66 inches into plate and then broke up. The point remained embedded in the plate, the remaining pieces being thrown out in front of the target. The front of plate showed, at the point of impact, an outward bulge of 1.77 inches, and in rear there were 3 short cracks, 2.76, 3.94, and 7.87 inches in length; the bulging out in the rear

was about .39 inch. The fourth projectile (Krupp) produced much the same results as the preceding one, the point penetrating about 7 inches, the shot breaking up. The fifth projectile (Krupp) from the 24-centimeter (9.45 inch) gun perforated the plate and backing, and remained in rear of butt. Its ogival head showed 3 fine cracks. The back of the plate was broken and bulged out 6.3 inches through a diameter of 24.41 inches, and the shock caused the head of No. 4 projectile to fall out. The two lower and two center bolts were found to be broken off.

The second trial was that of the Vickers homogeneous nickel-steel plate. The first shot (Streiteben) penetrated plate and backing 27.17 inches and remained. The edges of plate at point of impact were elevated some 1.78 inches. At the back the plate was broken and jagged out about 7.87 inches, and showed 5 surface cracks, while the point of the projectile projected in rear about 16.54 inches. The second shot (Krupp) penetrated 14.17 inches and remained. The edges of the plate at point of impact were raised 1.57 inches, while the back was broken and bulged 3.94 inches, with 3 surface cracks. The third shot (Streiteben) went through plate and backing, the edges at point of impact being elevated 1.57 inches, and in rear the plate was broken and bulged out 7.09 inches and showed, in addition, 4 surface cracks. The effect of the fourth shot (Krupp) was almost precisely similar, with 6 cracks in rear. The projectile (Streiteben) from the 24-centimeter (9.45-inch) gun went clean through the plate and backing and into butt. The face of plate at impact was crushed out 3.54 inches, and the back, through a diameter of 26.77 inches, was broken and bulged out 5.9 inches. All the bolts were found intact.

The Krupp Harveyed nickel-steel plate was next tested. The first projectile (Streiteben) shattered to fragments on impact, the point penetrating 2.76 inches and remaining flattened out: the face of plate showed a deep funnel-shaped fracture about 2.76 inches, with a diameter of 14.96 inches. In the neighborhood of point of impact exfoliations of the upper carbonized surface showed themselves; the back of plate was uninjured. The effect of the second shot (Krupp) was much the same, the exfoliations being 0.47 to 0.59 inch deep, while the back of plate was bulged 0.59 inch. The third projectile (Streiteben), after penetrating 11.81 inches, rebounded and remained intact a few paces to the right of the target. The plate was somewhat opened at the point of impact, and showed 3 fractures, 2 of which went through the plate and extended as far as the outer edge, while the third was neither so deep nor so extensive. The breadth of fractures was from 0.12 to 0.31 inch, and in the upper one a flaw in the metal reaching from point of impact to edge of plate was discovered; on the face exfoliations of the carbonized surface were visible. The back of plate displayed, besides the 2 fractures, 2 other surface cracks, and was bulged out some 3.14 inches. At this shot the head of the first projectile fell out. The fourth shot (Krupp) penetrated plate 12.6 inches, and then rebounded uninjured to

40 paces in front of target. The plate showed surface exfoliations, and the back was bulged out 4.72 inches, with 4 surface cracks. At the fifth round, fired from the 24-centimeter (9.45-inch) gun, the projectile (Krupp) penetrated through plate and backing, and was found broken into 2 fragments 20 paces in rear of target. The two large fractures in plate were opened out to a width of 4.33 inches and 7.08 inches, so that the right upper portion of plate was completely broken off; moreover, 2 new fractures right through the plate were disclosed at the point of impact, one of which extended to orifice made by No. 3 projectile, while the other extended to the outer edge, so that the left upper portion was also completely detached. A third fracture right through plate extended nearly to bottom from the center, while a slight surface crack was visible between fifth and third points of impact. The upper right hand and center securing bolts were broken.

The next trial was made with the Vickers Harveyed steel plate. The first projectile (Streiteben) broke, the head remaining embedded about 9.84 inches. The plate showed on its face several surface cracks, running from point of impact, with a crushing out of edges of 1.57 inches. The back of plate was bulged about 1.96 inches. The second shot (Krupp) remained embedded uninjured, having penetrated 12.6 inches through plate and backing, the head projecting 1.97 inches beyond rear face of plate, the edges of which were crushed out 1.97 inches, while there were several small surface cracks starting from the point of impact, and the usual crushing up of edge of plate round orifice of 1.57 inches. The third shot (Streiteben) produced similar results, the projectile penetrating through plate and backing 16.93 inches, and remaining embedded. The face of plate showed several short surface cracks and the customary raised edges of plate at orifice of 1.57 inches and bulging out 4.72 inches in rear. The fourth shot (Krupp) remained uninjured in plate, after penetrating 11.02 inches. The face showed some short surface cracks, while the back of plate was bulged some 1.97 inches. The 24-centimeter (9.45-inch) Streiteben shell broke upon impact, the point penetrating 12.6 inches, and remaining embedded.

The plate showed 3 fractures running from point of impact nearly to the edge. One fracture through plate from center to point of impact No. 3, and extending from there to upper edge, was 0.39 inch wide on the surface and 3.94 inches at the back; the second, running nearly horizontally from center to edge, was 0.12 inch in breadth, while the third, running toward the left bottom edge, was 0.394 broad in face and rear. In addition, the plate at back showed several surface cracks about 7.87 inches long, radiating from point of impact. The securing bolts were intact.

The next trial was of the nickel-steel plate of the Austrian firm of Witkowitz. The first shot (Streiteben) broke to pieces on impact, the head penetrating 3.94 inches, and remaining flattened out. The face

of plate showed the edges crushed up 1.38 inches round the 3.94 inches deep funnel-shaped orifice at point of impact, of 9.05 inches to 11.81 inches in diameter. The back of plate showed no signs of injury. The second shot (Krupp) remained intact, and rebounded 24 paces in front of target, having previously penetrated 13.39 inches; the back of plate was bulged out 2.36 inches, and showed 4 radial surface cracks. The third projectile (Streiteben) shattered on impact, the point penetrating 4.33 inches. The front of plate showed a funnel-shaped orifice about 11.81 inches in diameter; the rear surface showed no signs of injury.

The fourth shot (Krupp) broke up, the point remaining in plate; the edges of plate at impact were crushed up 1.78 inches, while in rear the plate was bulged to about the same extent, with 5 radial surface cracks. The 24-centimeter projectile (Streiteben) broke upon impact; the head, after penetrating 3.54 inches, rebounded in front of target, flattened out. A funnel-shaped orifice of 12.6 inches diameter and 3.54 inches deep was made in face of plate, while the back was bulged out some 0.394. The securing bolts remained intact.

The final trial was made with the Cammell nickel-steel plate. The first Streiteben shell penetrated plate and backing 19.7 inches and remained embedded uninjured. The edges of plate around point of impact were crushed out 1.57 inches, while in rear they were jagged and bulged out 5.51 inches, and there were several radial surface cracks. The point of projectile protruded 9.05 inches beyond rear surface of plate. The second projectile (Krupp) went clean through plate and backing, and could not be found. At point of impact edges of plate crushed up 2.36 inches, and in rear jagged and bulged 3.94 inches. The third projectile (Streiteben) penetrated 9.05 inches and then broke, the point remaining embedded; the back of plate was bulged 1.57 inches. The fourth shot (Krupp) broke, the point remaining in plate, having penetrated 16.93 inches into backing. The surface edges at point of impact were crushed up 1.57 inches, and in rear jagged and bulged 5.12 inches, with 6 radial surface cracks. The 24-centimeter (9.45-inch) Streiteben shell penetrated 11.81 inches and then broke, the point remaining embedded. The plate showed 3 through fractures. The first from point of impact V to I, and then to upper edge, with a maximum width of 0.43 inch on the face and 0.59 inch in rear. The second fracture passed through III to upper edge and was 1.18 inches wide in front and 1.57 inches in rear; while the third, passing through II to lower edge, was 2.6 inches in front and 2.2 inches in rear. The plate also showed on rear face a crack 0.039 to 1.3 inches wide from V through IV to lower edge. The four corner and right center bolts were bent.

The result of the trials was an undoubted success for the Austrian firm, to whom the contract for the armor for the new ships has now been given; and the Vickers firm have the satisfaction of knowing that their Harveyed steel plate came out a good second, and proved to be much superior to the plates of the three other competing firms.

The Messrs. Cammell intended to submit for the Pola trials, in addition to their nickel-steel plate, a Harveyed plate having no nickel, but the latter could not be prepared in time. It was given a separate trial in February last, at Messrs. Cammell's request. The size of the plate and firing conditions were the same as on the earlier occasion. The two Krupp and two Streiteben projectiles behaved about alike, all broke up, leaving the points embedded in the plate, so that the penetration could not be measured. There were no cracks. Each shot showed a bulge of about 0.25 inch on the rear side of plate.

The 9.45-inch projectile (Streiteben) penetrated about 12 inches and broke into 2 pieces of about equal size. The plate showed a horizontal through crack, over half an inch wide, reaching from the orifice to each side edge of the plate; a through crack about one-tenth of an inch wide, extending from the bottom of the orifice to the lower edge of the plate, and a through crack about one-tenth of an inch wide from upper edge of shot hole about halfway up to upper edge of plate. The behavior of the plate, while good, was not up to that of the Witkowitz plate.

The Witkowitz Company has acquired the right to use the Harvey process for treating armor plates, and the installation of the super-carburizing furnaces is about complete.

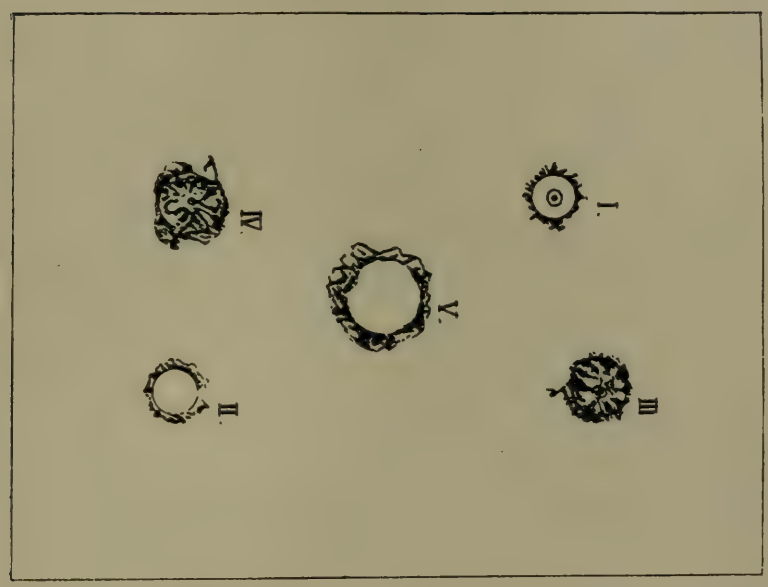
ENGLAND.

The explanatory statement of the first lord of the admiralty, accompanying the navy estimates for 1894–'95, contains the following remarks:

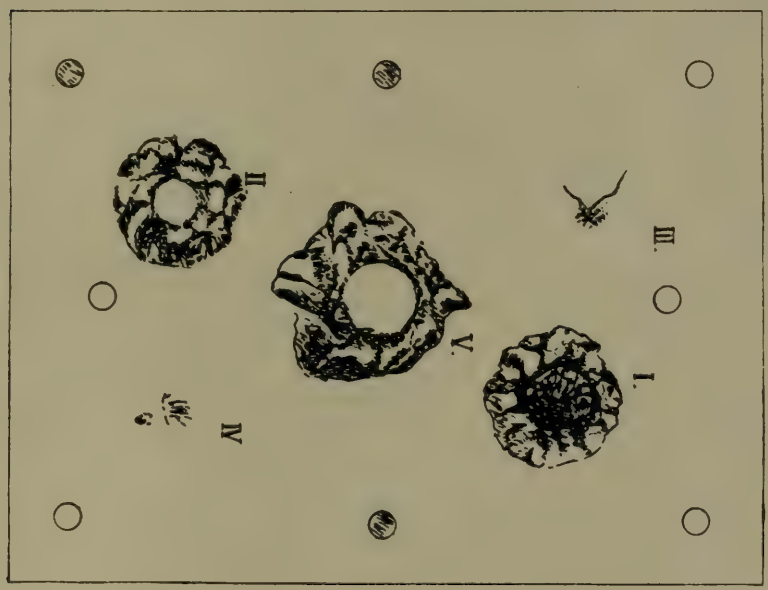
> The past year has been remarkable for the results obtained from experiments conducted with steel armor treated by the Harvey process. Armor plates supplied by four firms have been tested by and for the admiralty. The investigation has been most thorough and extensive, and, as a result, orders have been given for Harveyed steel armor for the *Renown*, *Majestic*, and *Magnificent*. It has been established that Harveyed plates without nickel in the steel show resistance to modern projectiles as great as any hitherto obtained when nickel was combined with steel in plates also treated by the Harvey process. The consequence of adopting this new system will be a great saving in cost for a given defense. By means of these improvements the power of defense obtainable with certain thicknesses and weights of armor has been very greatly increased, and this circumstance must considerably affect the designs of battle ships to be laid down in the future.

Mr. Vickers claims that the British Government began to take nickel out of armor plates at his suggestion. A plate was first tried with half the usual amount of nickel, and then one was tried without any nickel at all. Mr. Vickers also claims that the tests made in England between Harveyed plates, with and without nickel, are final and conclusive in favor of not using nickel.

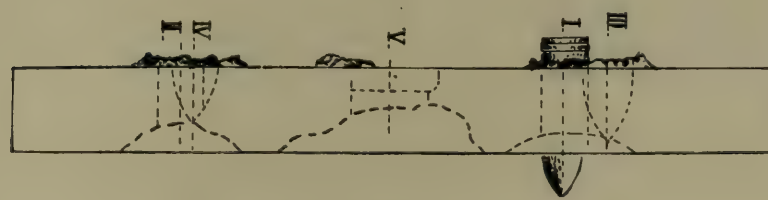
The admiralty wishing to ascertain the value of the Harvey process, ordered from Vickers & Co. a large plate, which was to be cut in half,



Face.

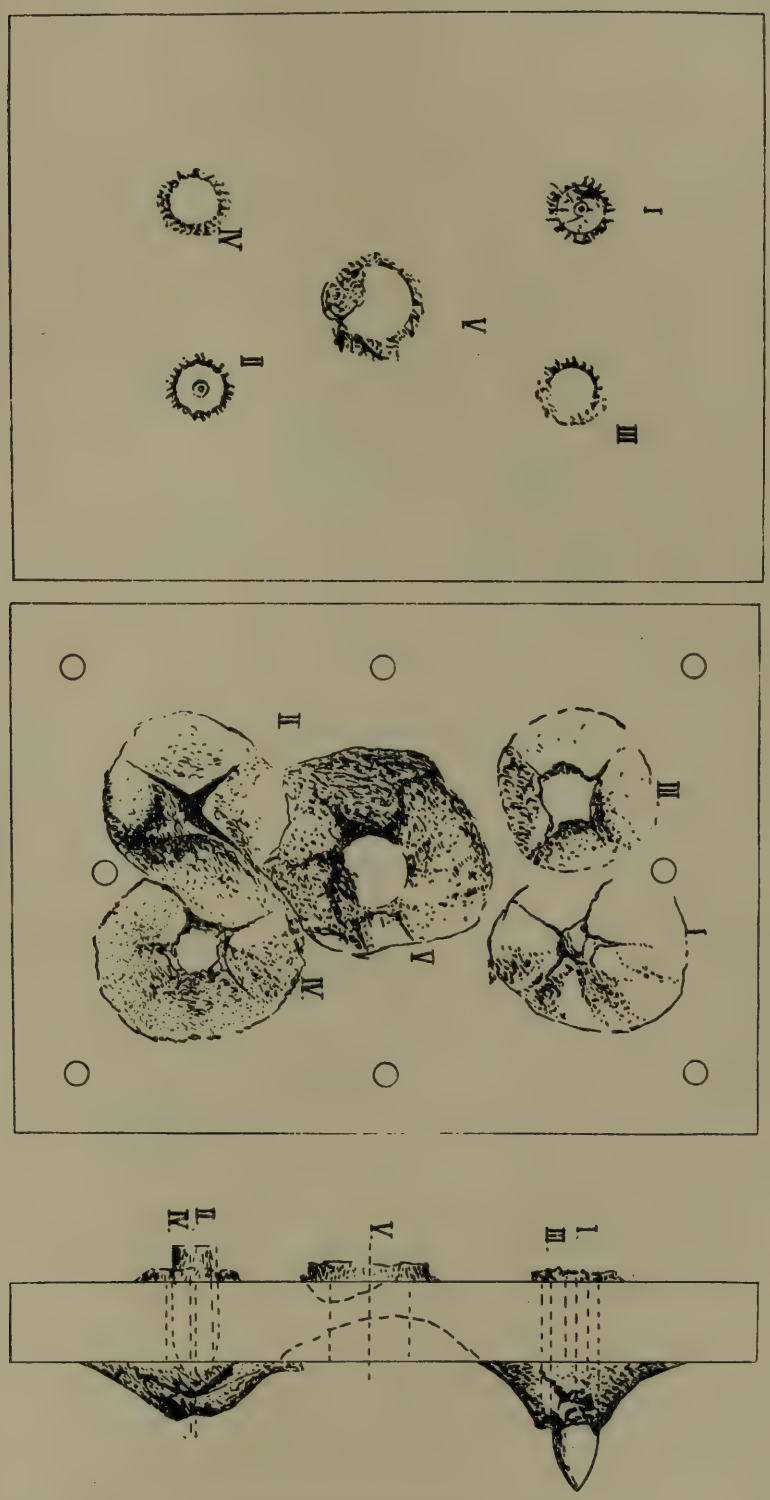


Back.



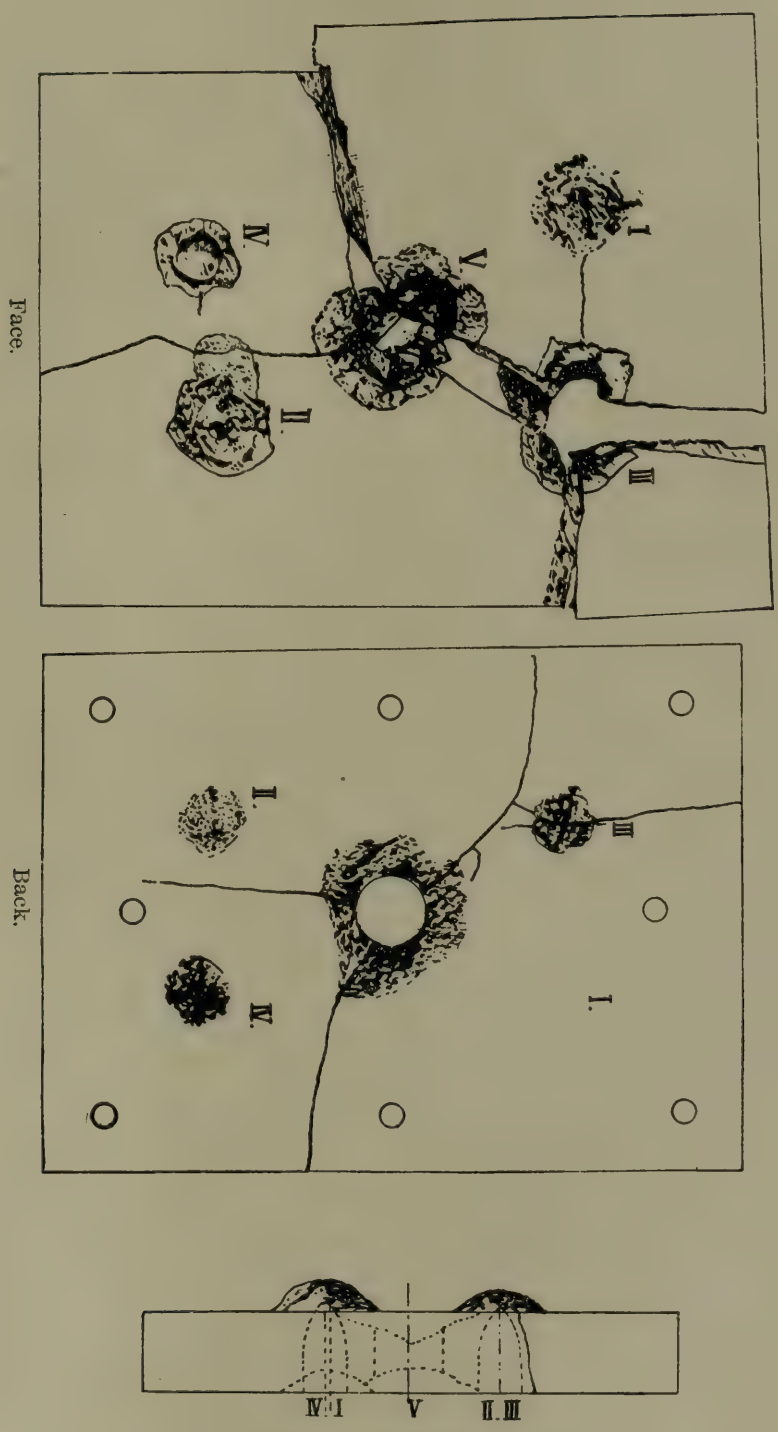
DILLINGEN COMPANY'S PLATE.

Dimensions, 7′ x 6′ x 10″.8.



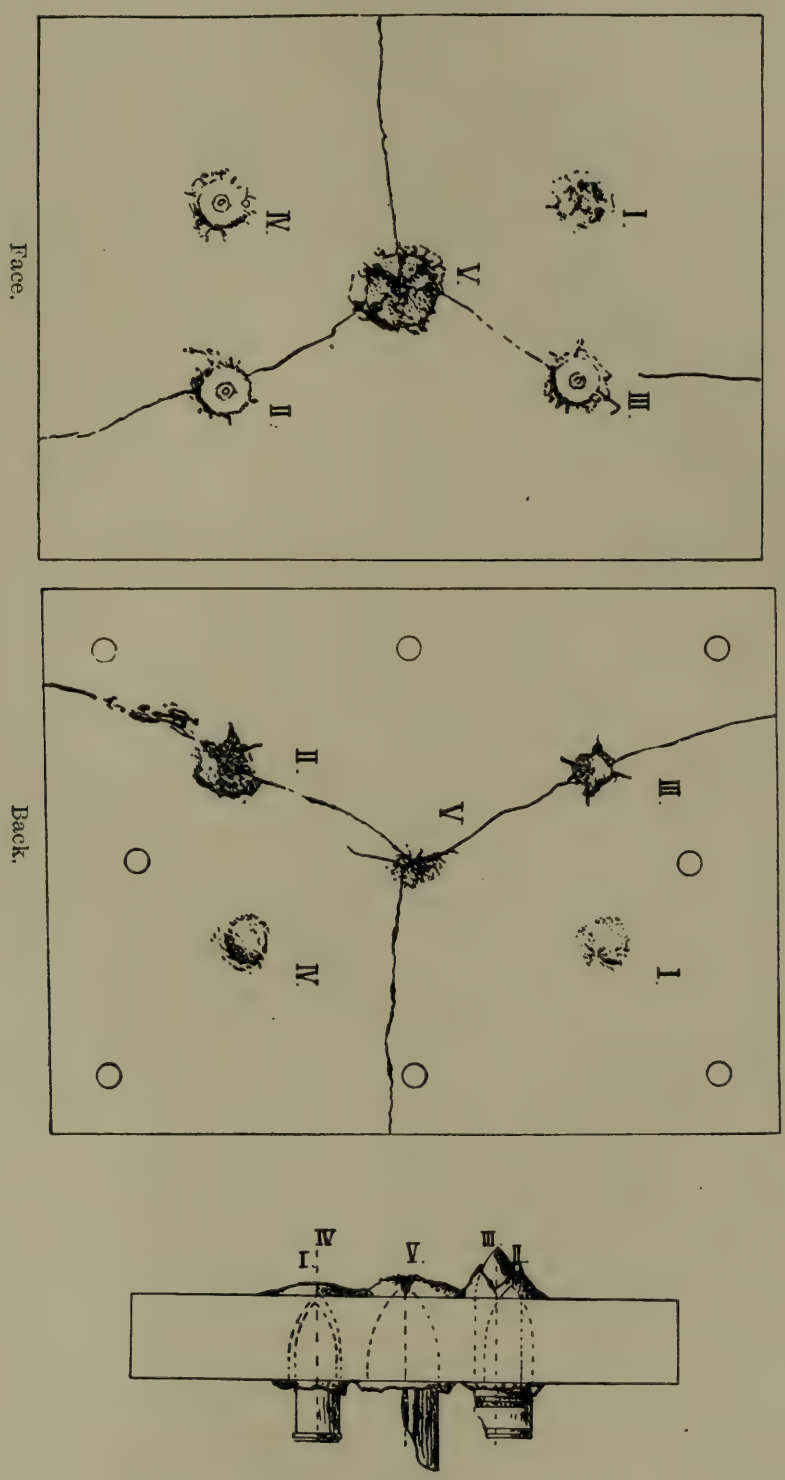
VICKERS AND COMPANY'S PLATE.

Dimensions, 7′ x 6′ x 10″.8.



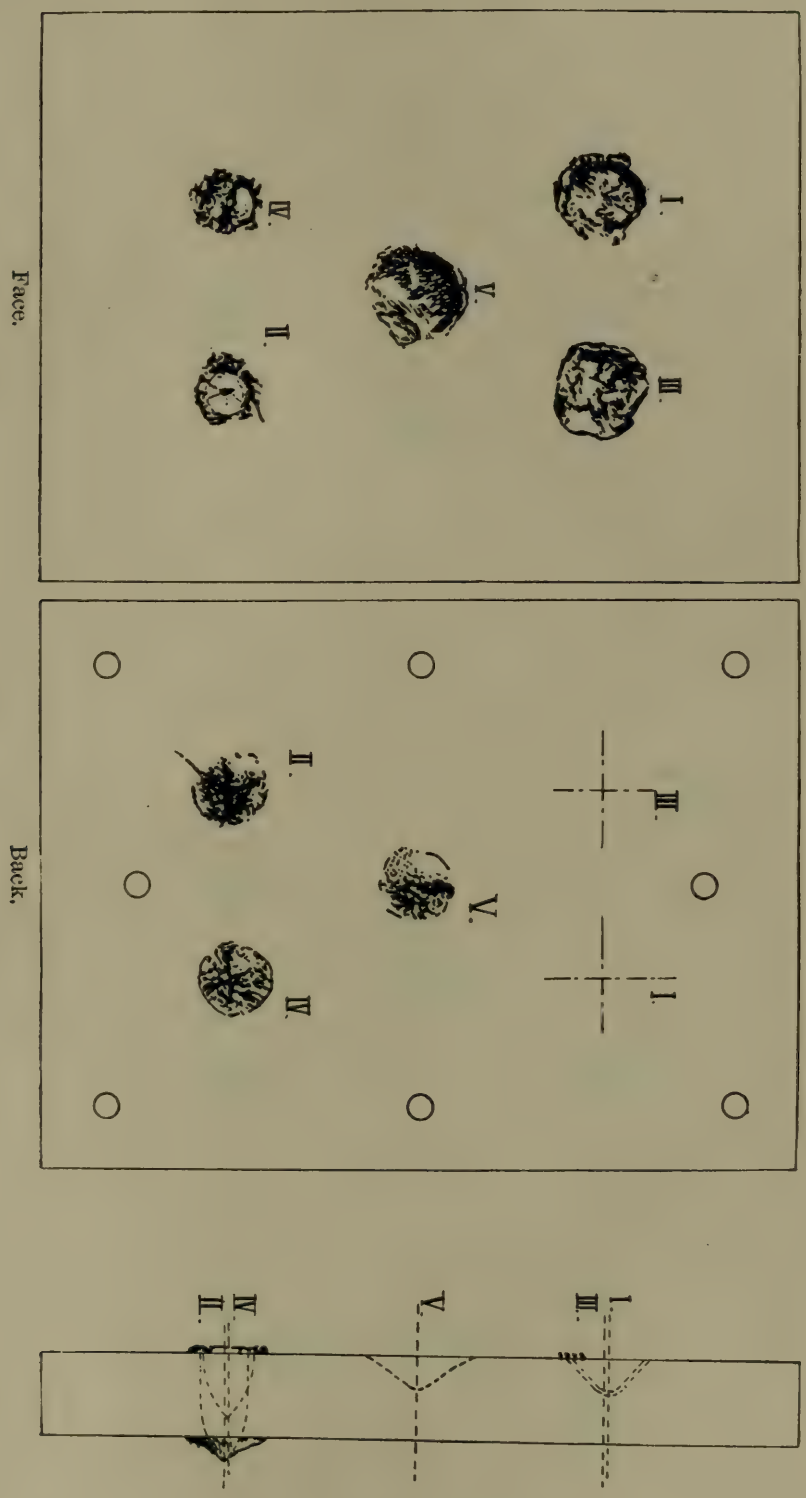
KRUPP AND COMPANY'S PLATE.

Dimensions, 7′ x 6′ x 10″.8.



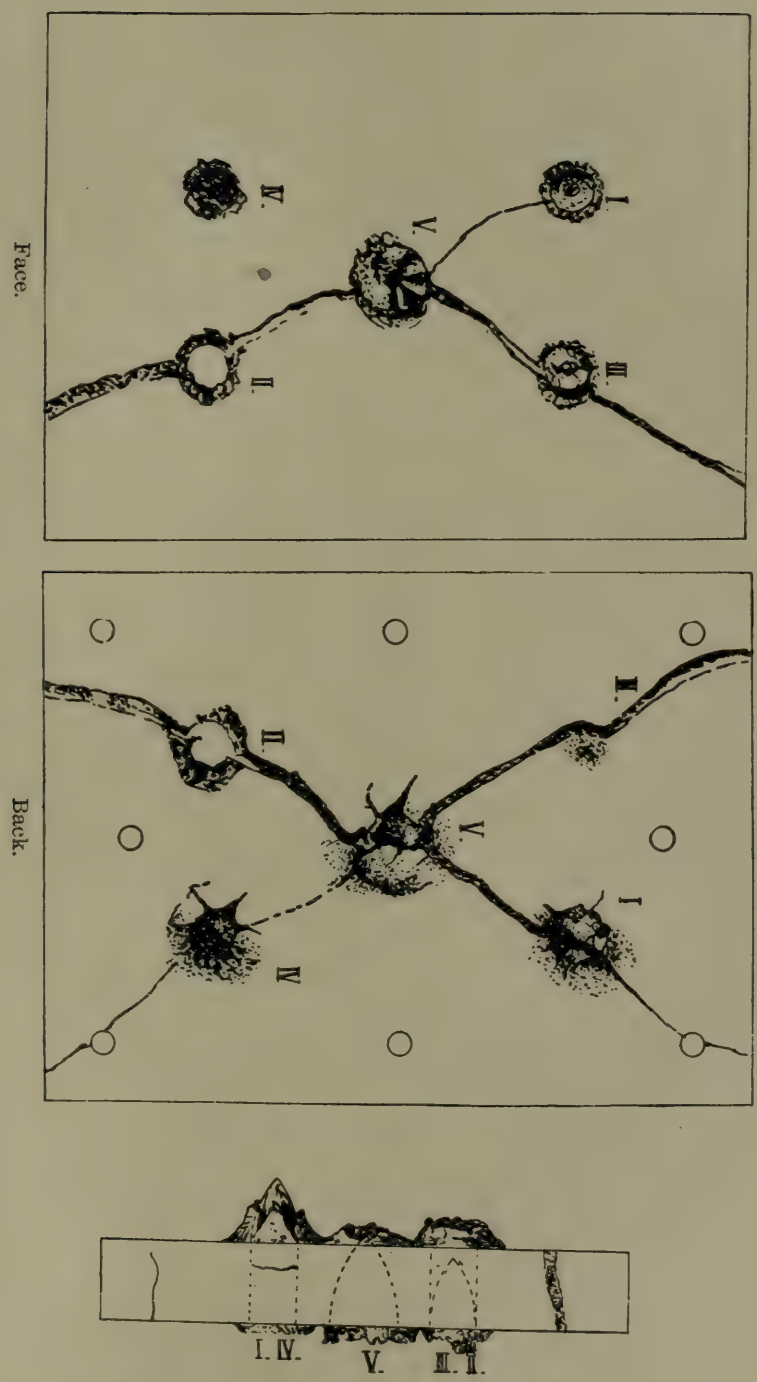
VICKERS AND COMPANY'S SECOND PLATE.

Dimensions, 7′ x 6′ x 10″.8.



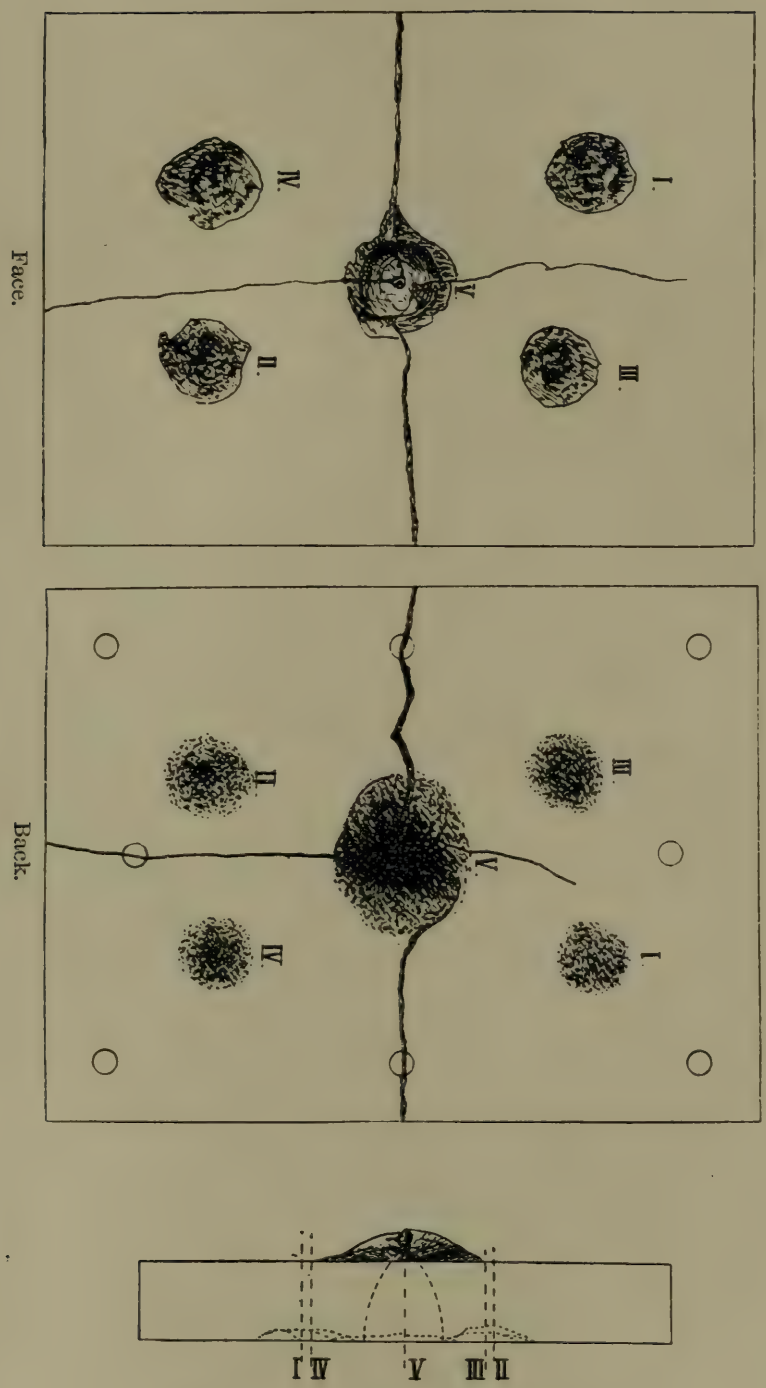
WITKOWITZ AND COMPANY'S PLATE.

Dimensions, 7′ x 6′ x 10″.8.



CAMMELL AND COMPANY'S PLATE.

Dimensions, 7′ x 6′ x 10″.8.



CAMMELL AND COMPANY'S SECOND PLATE.

Dimensions, 7′ x 6′ x 10″.8.

and one-half Harveyed, the other being left untreated, and tried them with the following results:

HARVEYED 6-INCH STEEL ARMOR PLATE TESTED ON BOARD THE NETTLE, JANUARY 19, 1893.

The 6-inch breech-loading gun was used firing Holtzer-forged steel projectiles weighing 100 pounds each. The trial was of a most unusual kind, the guns and projectiles being those regularly employed for testing 10½-inch plates.

Round 1: Charge, 30½ pounds; striking velocity, 1,507 foot seconds; striking energy, 1,575 foot tons. Projectile was pulverized without cracking or injuring plate.

Round 2: Charge, 42 pounds (full service); striking velocity, 1,815 foot seconds; striking energy, 2,204 foot tons. Shot again broken up but plate cracked.

Round 3: Forty-eight pounds (battering charge); striking velocity, 1,960 foot seconds; striking energy, 2,664 foot tons. Projectile just perforated plate and lodged in form of fragments in backing.

Round 4: Forty-two pounds (full-service charge); striking velocity, 1,818 foot seconds; striking energy, 2,694 foot tons. Shell again broken up without perforation.

UNTREATED 6-INCH STEEL PLATE, TESTED MARCH 1, 1893.

Round 1: (Holtzer shell), charge 30½ pounds; striking velocity, 1,507 foot seconds; striking energy, 1,575 foot tons. The shell perforated the plate and lodged in the backing.

Round 2: (Palliser shot), charge 30½ pounds; striking velocity, 1,507 foot seconds; striking energy, 1,575 foot tons. The shot was stopped and broken up, point imbedded in plate.

Round 3: (Palliser), charge 36½ pounds; striking velocity, 1,690 foot seconds; striking energy, 1,979 foot tons. The projectile perforated plate and penetrated backing to a depth of 3 feet.

Round 4: (Holtzer), charge 24½ pounds; velocity not calculated. Shell perforated plate, penetrated backing to a depth of 2.1 inches and rebounded.

Round 5: (Holtzer), 27½ pounds charge; velocity not calculated. Shell perforated plate, penetrated backing 3.1 inches and rebounded.

The result of the test left no doubt as to the superior protective value of the half which had been treated by the Harvey process.

On March 15 last, Mr. C. E. Ellis, manager of the firm of John Brown & Co., read an excellent paper on "Recent experiments in armor" before the Institution of Naval Architects, in which he pointed out the great improvements which have been effected during the last few years, especially in England. He estimated that the resisting power of plates, as at present made, with hardened faces, is at least 50 per cent greater than that of the predecessors of 1888. A table of results obtained with many of the treated plates fired at was given, from which the following data relating to the English experiments is extracted:

Results of recent experi

Manufacturer.	Description of plate.	Date of trial.	Place of trial.	Size of plate. Length.	Size of plate. Width.	Size of plate. Thickness.	Caliber of gun.	Projectile. Weight.	Projectile. Velocity.	Projectile. Description.
				Ft. In.	*Ft. In.*	*In.*	*In.*	*Lbs.*	*Feet.*	
Vickers	Nickel steel.	Aug. 23, 1893	Texel	6 7¾	4 11	5.9	4.72	57.32	1,443	Krupp's steel.
									1,574	do
									1,640	do
									1,771	do
									1,880	do
Cammell	do	do	do	6 7¾	4 11	5.9	4.72	57.32	1,443	do
									1,574	do
									1,640	do
									1,771	do
									1,880	do
John Brown & Co.	do	do	do	6 7¾	4 11	5.9	4.72	57.32	1,443	do
									1,574	do
									1,640	do
									1,771	do
									1,880	do
Vickers	do	Jan. 18, 1893	H. M. S. Nettle.	8 0	6 0	6	6	100	1,507	Holtzer
									1,815	do
									1,960	do
									1 815	do
Vickers	do	Aug. 15, 1893	do	8 0	6 0	6	6	100	1,507	do
									1,815	do
									1,815	do
									1,960	do

ments with English armor.

T = Thickness of wrought iron the shot would perforate, Gavre formula.	Proportion of T to thickness of plate (= 100).	T_1 = Thickness of wrought iron the shot would perforate according to De Marre's formula.	Proportion of T_1 to thickness of plate (= 100).	Result.	
				On plate.	On projectile.
Inches.		*Inches.*			
5.65	95	7.2	122	Penetration, 6.9 inches; no cracks.	Rebounded intact.
6 35	107	8.15	138	Penetration, 8.1 inches; no cracks.	Do.
6.72	113	8.63	146	Penetration, 2.4 inches; no cracks.	Shot broken, head remaining in plate.
7.5	127	9.65	163	Penetrated, 1 fine crack visible..	Broken up, head remaining embedded in plate.
8.18	138	10.5	177	Some penetration, but backing uninjured; serious through cracking, but the plate remains integral part of the target.	Do.
5.65	95	7.2	122	Penetration, 6.9 inches; no cracks.	Rebounded intact.
6.35	107	8.15	138	Penetration, 11.6 inches; no cracks	Broken, head remaining in plate.
6.72	113	8.63	146	Complete, perforation; no cracks.	Small longitudinal cracks. Slightly set up.
7.5	127	9.65	163	.....do	Projectile recovered with considerable longitudinal crack; slightly set up.
8.18	138	10.5	177	.....do	Not recovered.
5.65	95	7.2	122	Penetration, 7 inches; no cracks.	Rebounded.
6.35	107	8.15	138	Penetration, 2.5 inches; no cracks.	Completely broken up, head embedded in plate.
6.72	113	8.63	146	Penetration, 16 inches; no cracks.	Stuck in plate.
7.5	127	9.65	163	Penetration, 6.3 inches; no cracks.	Broken, head remaining embedded in plate.
8.18	138	10.5	177	Complete perforation of plate and backing.	Not recovered.
7.5	125	8.85	147	Penetration, 6.35 inches; height of bulge, 0.7 inch; no cracks.	Broken up.
9.75	162	11.55	192	Penetration, 11.5 inches; several cracks; height of bulge, 3.25 inches.	Broken up, point remained in plate.
10.8	180	12.9	215	Penetration, 13.5 inches; several cracks; height of bulge, 1.5 inches.	Broken up, point remained in backing.
9.75	162	11.55	192	Penetration, 6.25 inches; several cracks; height of bulge, 3 inches.	Broken up, point remained in plate.
7.5	125	8.85	147	Penetrated; no cracks; height of bulge, 1⅛ inches.	Stopped and broken up.
9.75	162	11.55	192	Complete perforation; no cracks.	Broken up, point remaining in backing.
9.75	162	11.55	192	Penetrated; no cracks; height of bulge, 2¼ inches.	Stopped and broken up, part remaining in plate.
10.8	180	12.9	215	Complete perforation; no cracks.	Passed through plate and backing unbroken.

Results of recent experiments

Manufacturer.	Description of plate.	Date of trial.	Place of trial.	Size of plate.			Caliber of gun.	Projectile.		
				Length.	Width.	Thickness.		Weight	Velocity.	Description.
				Ft. In.	*Ft. In.*	*In.*	*In.*	*Lbs.*	*Feet.*	
John Brown & Co.	Nickel steel.	.....	H. M. S. Nettle.	8 0	6 0	6	6	100	1,507	Krupp's steel.
									1,815	....do .....
									1,960	....do .....
									1,815	....do .....
Vickers	Steel..	June 30. 1893	...do	8 0	6 0	6	6	100	1,507	....do .....
									1,815	....do .....
									1,960	....do .....
									1,815	....do .....
Cammell	...do ...	Nov. 8, 1893	...do	8 0	6 0	6	6	100	1,507	....do .....
									1,815	....do .....
									1,960	....do .....
John Brown & Co.	...do ...	Feb. 7, 1894	...do	8 0	6 0	6	6	100	1,507	....do .....
									1,815	....do .....
									1,960	....do .....
									1,815	....do .....
Vickers	Nickel steel.	Nov. 1, 1892	...do	8 0	6 0	10.5	6	100	1,973	Holtzer...

with English armor—Continued.

T = Thickness of wrought iron the shot would perforate, Gavre formula.	Proportion of T to thickness of plate (= 100).	T_1 = Thickness of wrought iron the shot would perforate according to De Marre's formula.	Proportion of T_1 to thickness of plate (= 100).	Result.	
				On plate.	On projectile.
Inches.		*Inches.*			
7.5	125	8.85	147	Slight penetration; no cracks; height of bulge, 1⅜ inches.	Completely broken up, head remaining in plate.
9.75	162	11.55	192	Penetration, 11 inches; 1 crack and 1 hair line.	Broken up, head remaining in plate.
10.8	180	12.9	215	Complete perforation; 1 crack...	Broken up, part being found 9 inches in backing.
9.75	162	11.55	192	Complete perforation	Broken; part found behind backing.
7.5	125	8.85	147	Penetrated; 1 crack in plate; height of bulge, 2 inches.	Completely broken up; point embedded in plate.
9.75	162	11.55	192	Penetrated; some cracks; height of bulge, 3 inches.	Do.
10.8	180	12.9	215	Penetrated; further cracking; height of bulge, 4½ inches.	Do.
9.75	162	11.55	192	Penetration, 11 inches; slight increase of cracking; back of plate where struck broken away; height of bulge, 3½ inches.	Projectile remained in plate, base projecting 6 inches from face; some part of projectile broken.
7.5	125	8.85	147	Very slight penetration; face at point of impact forced back 1½ inches; 2 fine cracks and 1 hair crack; height of bulge, ⅞ inch.	Completely broken up.
9.75	162	11.55	192	Penetration, estimated, 3 inches; 3 fine cracks; height of bulge, 2⅞ inches; indent in backing, 2 inches deep.	Point remained in plate; remainder completely broken up into small pieces.
10.8	180	12.9	215	Perforation, about 3⅜ inches; point of cone, 2⅛ inches inside face of plate; 4 more cracks formed, but plate remained entire; height of bulge, 3⅞ inches; indent in backing, 3 inches deep.	Point remained in plate; remainder completely broken up into small pieces. A small piece of plate remained in backing.
7.5	125	8.85	147	Penetration, 1.7 inches; some fine hair cracks.	Broken up.
9.75	162	11.55	192	Penetration, estimated, 7 inches; several cracks.	Do
10.8	180	12.9	215	Plate perforated; cracks extended.	Broken up; portion of fragments in backing and some in front of target.
9.75	162	11.55	192	Penetration, estimated, 6 inches; one slight additional crack.	Broken up.
11	104	12.95	123	Penetration, estimated, 4 inches; no cracks; height of bulge, 0.4 inch.	Broken up point; embedded in plate.

Results of recent experiments

Manufacturer.	Description of plate.	Date of trial.	Place of trial.	Size of plate.			Caliber of gun.	Projectile.		
				Length.	Width.	Thickness.		Weight.	Velocity.	Description.
				Ft. In.	*Ft. In.*	*In.*	*In.*	*Lbs.*	*Feet.*	
Vickers	Nickel steel.	Nov. 1, 1892.	H. M. S. Nettle	.....	.....	.....	.....	100	1,973	Holtzer
								98	1.973	Palliser
								98	1.973	do
								100	1 973	Holtzer
		June 1, 1893	Shoeburyness.	.....	.....	.....	9.2	380	1,698	do
									1.808	do
Cammell	do	May 12. 1893	H. M. S. Nettle.	8 0	6 0	10.5	6	100	1.960	do
								100	1,960	do
								98	1,960	Palliser
								98	1,960	do
								100	1,960	Holtzer
		Aug. 31, 1893	Shoeburyness.	.....	.....	.....	9.2	380	1,808	do
							9.2	380	1,948	do
John Brown & Co.	do	Oct. 10, 1893	do	8 0	6 0	10.5	9.2	380	2,035	do
							9.2	380	1,807	do
										do
Cammell	Nickel steel (curved to predetermined lines).	Nov. 9, 1893	do	8 0	6 0	10.5	9.2	380	2,035	do
John Brown & Co.	Steel (curved todetermined lines).	Oct. 26. 1893	do	8 0	6 0	10.5	9.2	380	2,035	do

with English armor—Continued.

T=Thickness of wrought iron the shot would perforate, Gavre formula.	Proportion of T to thickness of plate (=100).	T_1=Thickness of wrought iron the shot would perforate according to De Marre's formula.	Proportion of T_1 to thickness of plate (=100).	Result.	
				On plate.	On projectile.
Inches.		*Inches.*			
11	104	12.95	123	Penetration, estimated, 4 inches; no cracks; height of bulge, 0.5 inch.	Broken up point; embedded in plate.
10.8	102	12.8	121	Penetration, estimated, 3 inches; no cracks; height of bulge, 0.3 inch.	Do.
10.8	102	12.8	121	Penetration, estimated, 3 inches; no cracks; height of bulge, 0.15 inch.	Do.
11	104	12.95	123	Penetration, estimated, 4 inches; no cracks; height of bulge, 0.4 inch.	Do.
17	161	17.25	164	Penetration, about 6 inches; plate divided into 2 pieces.	Broken up, head remaining in plate.
18.5	176	18.8	179	Penetration, about 9.2 inches; plate much shattered.	Do.
10.8	103	12.9	122	Penetration, slight; no cracks; height of bulge, $\frac{5}{16}$ inches.	Completely pulverized.
10.8	103	12.9	120	.....do.....	Do.
10.7	101	12.7	120	Penetration, slight; no cracks; height of bulge, $\frac{1}{4}$ inch.	Do.
10.7	101	12.7	120	Penetration, slight; no cracks; height of bulge, $\frac{1}{8}$ inch.	Do.
10.8	103	12.9	122	Penetration, slight; no cracks; height of bulge, $\frac{3}{8}$ inch.	Do.
18.5	176	18.8	179	Penetration, 8 inches; 1 through crack across face.	Do.
20.3	193	21	200	Penetration through plate; point, 18 inches in backing; plate broken into 3 pieces.	Greatly shattered.
22	209	22.4	213	Penetration, through plate; 5 radial cracks.	Broken up but remained in plate.
18.6	177	18.8	179	Plate perforated and broken.....	Broken up.
13.9	132	14.8	140	Same as rounds 1 and 2.....	Same as rounds 1 and 2.
22	209	22.4	213	Penetration to depth of about 10 inches; 4 through cracks radiating from point of impact.	Base portion found 7 feet in front of target; remainder stuck in plate, but broken, and point destroyed.
22	209	22.4	213	Plate perforated; four radial cracks.	Shot broken up; head in backing; about one-third of projectile thrown back in one piece in front of target.

FRANCE.

During the summer of 1893 some Harveyed nickel-steel plates were ordered from Vickers & Co., England, for trial at Gavre, to establish the comparative merits of the Harveyed plates and plates of St. Chamond special steel. The first of these plates was tried on April 12, 1893, the trial being begun with a velocity equivalent to that required to perforate a St. Chamond special steel plate of the same dimensions. The dimensions of the plate were 8 feet by 6 feet by 10.55 inches, and its weight was 10.7 tons. The plate was secured by twelve 2.36-inch bolts to a heavy oak backing, and lateral movement was prevented by bolting an old armor plate on each side. The gun used was a new model 240-millimeter (9.45-inch), having a length of bore of 42 calibers. The projectiles were of St. Etienne chrome steel, weighing 317 pounds each. Smokeless powder, in charges graduated to obtain the necessary velocities, was used. The required velocity was calculated to be 1,902 foot seconds.

First shot: Impact near center vertical line, about 2 feet from the top of plate. The projectile penetrated to a depth of 6.61 inches, broke up, and rebounded, the head being badly set up. The plate was seriously cracked, and there was considerable scaling around the hole, which was about 12.6 inches in diameter.

Second shot: Striking velocity, 2,296 foot seconds. Projectile similar to the first one used. Impact at about 18 inches from the left edge and 2 feet from the top of plate. The plate was perforated, the projectile being recovered about 1,300 yards in rear of the target, its point somewhat defaced. The hole made in the plate was very ragged, and the plate was broken between the cracks made by the first shot. New cracks appeared, and 3 bolts were badly twisted.

Third shot: Striking velocity 2,132 foot seconds. Projectile same as before. Impact at 1.5 feet from right edge and 2 feet 8 inches from bottom of plate. The plate was perforated, and the projectile was recovered about 200 yards in rear of the target, considerably deformed and the point broken off. A fragment of the plate, between two of the fine cracks, was thrown off, as were also several smaller fragments left on the backing after the previous shot. Two bolts were broken off and fell down.

Fourth shot: Striking velocity 2,132 foot seconds. Projectile similar to the others fired. Impact about center of a triangular fragment 1.4 feet from the left edge and 1.5 feet from bottom of plate. The projectile penetrated until the point touched backing and broke up, the body falling in front of target and the head remaining fused in the plate.

The second trial was made under somewhat different conditions. The plate was thicker and was somewhat curved; moreover, it was attacked by a more powerful gun. The dimensions of the plate were 9 feet by

7 feet by 14.49 inches, and its weight 16.5 tons. The plate was curved to a radius of 6.6 feet. It was secured to the oak backing in the manner customary at Gavre, with sixteen 2.4-inch bolts. The gun was a 34-centimeter (13.4-inch), and the projectiles, of St. Chamond steel, weighed 926 pounds each. The striking velocity of first shot was 2,050 foot seconds. The projectile perforated plate and backing and was recovered broken up about 55 yards beyond the target. The plate was split through and a portion detached laterally, about 20 inches. The velocity of the second shot was 1,772 foot-seconds, the projectile being similar to the first one. The projectile passed through the plate and backing and was recovered about 200 yards in rear of the target, practically intact. The plate was wrecked and the greater portion of the target fell to the ground.

A specimen of some nickel-steel armor-plates which were manufactured at Le Creuzot for the new Russian battle ship *Tri Sviatitelia* was tried at Le Creuzot in the presence of the members of the Russian naval commission, and gave some remarkable results. The plate measured 8 by 8 feet, and was 15.9 inches thick. The conditions of acceptance were that it should receive four blows from Holtzer projectiles of chrome steel, weighing 317 pounds each, and fired from a 240-millimeter (9.45 inch) gun, with a striking velocity of 1,945 foot seconds; and it was stipulated that no piece of the target should be broken off, and that in no case should the base of the projectile penetrate the target to a depth of as much as 7.8 inches.

The four rounds were fired at the angles of a square, which was painted on the center of the target, and which measured 4 feet each way. The order of the shots was—(*a*) right lower corner, (*b*) left lower corner, (*c*) left upper corner, (*d*) right upper corner, and the following were the striking velocities and injuries to projectile and plate:

(*a*) Velocity, 2,001 foot seconds. Penetration of the point of the projectile, 14.1 inches. The projectile flew backwards with the point smashed, and the shoulder somewhat set up. The target showed three very fine cracks running from the point of impact.

(*b*) Velocity, 1,948 foot seconds. Penetration of the point of the projectile, 10.9 inches. The projectile flew backwards, broken into numerous fragments. As before, three fine cracks developed in the target.

(*c*) Velocity, 1,923 foot seconds. Penetration of the point of the projectile, 14 inches. The projectile flew back with the head smashed, and the cylindrical part somewhat set up. A single fine crack was remarked.

(*d*) Velocity, 1,962 foot seconds. Penetration of the point of the projectile, 9.9 inches. The projectile flew backwards, broken into numerous fragments. There were no fresh cracks, and the old ones were not increased.

Examination of the back of the target revealed the existence of low swellings, varying from 1 inch to 1.7 inches in elevation, behind each

point of impact. Behind points (*a*) and (*b*) there were some fine cracks; behind points (c) and (*d*) no cracks were apparent.

The firms of St. Chamond, Chatillon-Commentry, Marrel Frères, and St. Etienne, entered into a contract some time since by which they acquired the right to use the Harvey process of face hardening. M. Schneider, of Creuzot, who declined at first to join the syndicate, is said to have since decided to do so. A number of experimental plates have been tested at the proving ground of the St. Chamond establishment in the interest of the whole syndicate, and some very interesting results have been obtained.

By the courtesy of the Chatillon-Commentry Company the following account of an interesting trial on September 26, 1893, with a St. Jacques Harveyed plate is given.

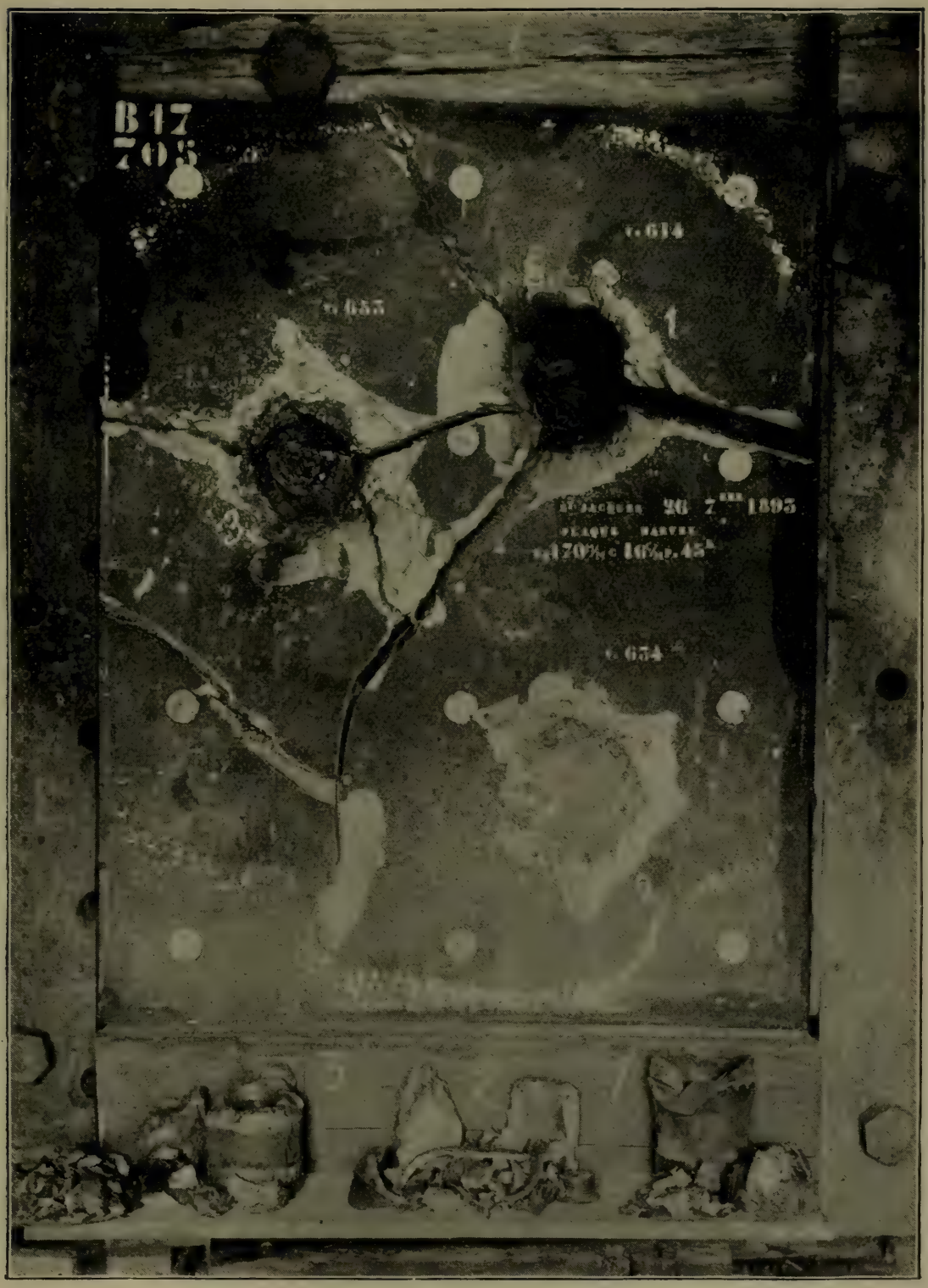
The dimensions of the plate were 5.25 feet by 4.25 feet by 6.69 inches, and its weight 6,030 pounds. It was secured by 12 bolts to a wood backing of the Gâvre type, being held in place laterally by 2 old armor plates. The gun used was a 164.7-millimeter (6.48-inch) B. L., and the projectiles were steel forged, weighing 99.2 pounds each. The plate was 49.21 feet from the muzzle of the gun.

First shot: At upper right-hand corner of the plate, about 18 inches from edges. Charge, 56.4 pounds P. B. 3 S. Striking velocity, 2,014 foot seconds. The projectile remained in the plate, its base projecting about 1 caliber. The head was broken. A crack was produced in the plate extending from the orifice to the adjoining edge of plate, and there was considerable scaling around the point of impact.

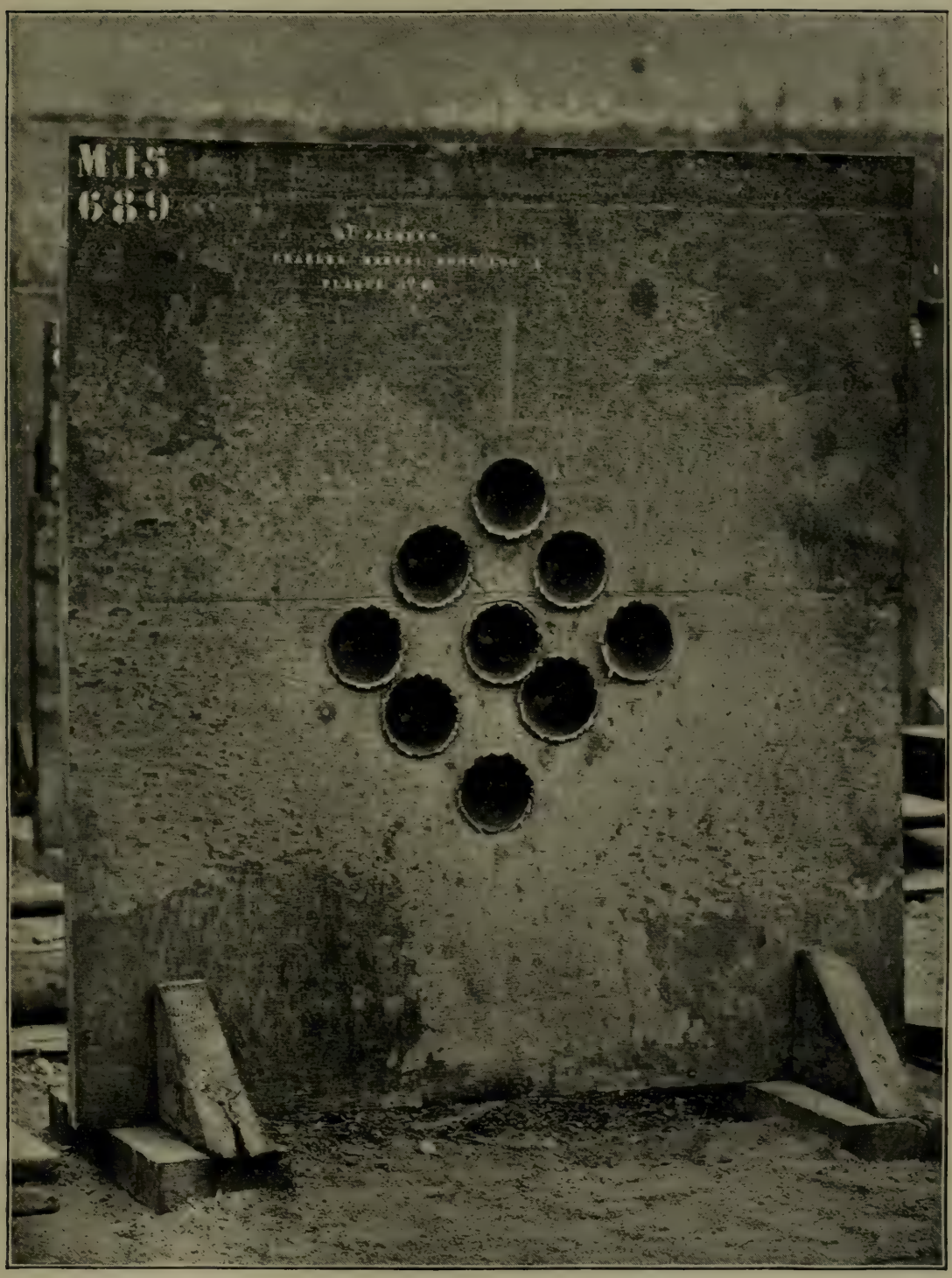
Second shot: Lower right-hand corner, at 18.1 inches from edges. Projectile same type as before. Charge, 59.3 pounds P. B. 3. Striking velocity, 2,080 foot seconds. The projectile broke up into numerous fragments. The ogival remained in the plate. Two new cracks appeared, extending from impact No. 1 to the top and lower edge of plate, respectively. The base of the first projectile fell out, and it was seen that some fragments of the head had penetrated some distance into the backing.

Third shot: Left side of plate at 22.83 inches from top, and 13.78 from left edge. Charge, 62.2 pounds P. B. 3 S. Striking velocity, 2,142 foot seconds. The projectile broke into numerous fragments, one portion of the base being recovered 32.8 feet in front of target, and a part of the ogival remaining embedded in the plate. New cracks were produced and the old ones were considerably enlarged. (*See* figure.) The ogive of the second projectile fell out, and it was found that the penetration of this shot was 3.1 inches.

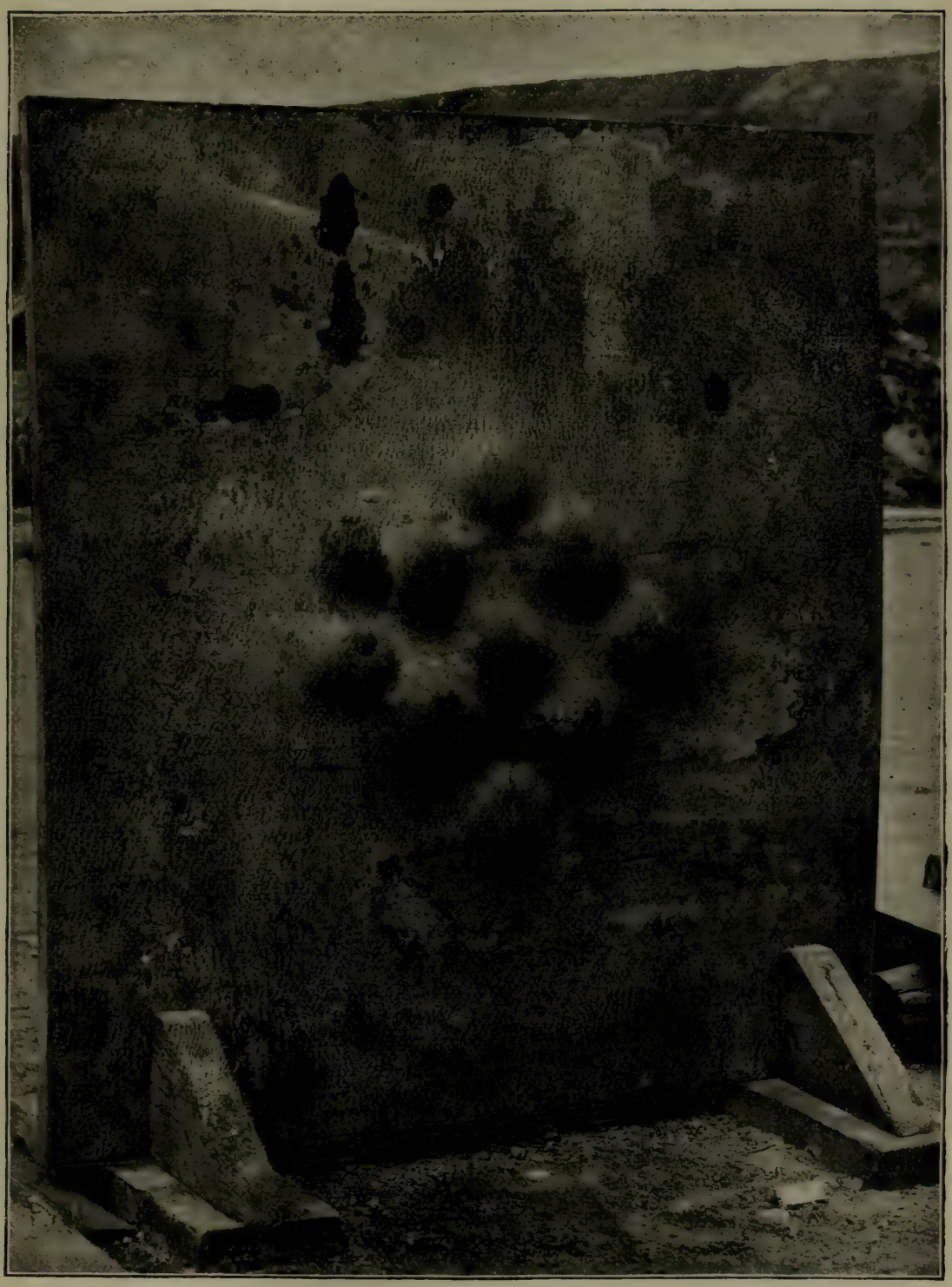
Until recently the protective deck-plates in French war vessels have been of iron, for the reason that steel plates when attacked by heavy projectiles, although possessing greater resistance, cracked and shattered under the inclined fire. The St. Jacques Works, at Montluçon, of the Chatillon-Commentry Company, solved this difficulty by pro-



CHATILLON-COMMENTRY HARVEYED ST. JACQUES PLATE.



FRONT VIEW OF DECK-PLATE OF ST. JACQUES METAL.



REAR VIEW OF DECK-PLATE OF ST. JACQUES METAL.

ducing a material known in the French service as "métal St. Jacques," an extremely mild and tenacious steel, and the success attained has induced the other steel manufacturers to attempt the production of a similar metal, and the ministry now requires a metal which will fulfill the conditions obtained with the "métal St. Jacques."

As an illustration of the excellence of this metal, the following report of a trial, made on September 6, 1893, at Montluçon, of a piece cut from one of the deck-plates of the battleship *Charles Martel*, is given:

The dimensions of the plate were: 5.31 by 4.92 feet by 2.76 inches, and the gun used was a 164.7-millimeter (6.48-inch). The projectile was of chilled cast iron, weighing 99.2 pounds; striking velocity, 535 feet. The customary 5 shots at the middle were fired upon the angles and center of a square of which the sides were 9.84 inches. The supplementary shots were placed relatively to the preceding ones, according to the same rule. Under this exceptionally severe trial the plate remained without cracks after the first 5 shots. A slight tear was apparent after the sixth shot, between holes No. 2 and No. 5, but this was not appreciably increased under the succeeding impacts. The mean penetration of the first and fifth shots was 3.74 inches, height of fringe about orifice 0.63 inch, and diameter of the bottom of orifice 4.64 inches.

A trial of some French surface-hardened plates took place at Gâvre, in April last. The firms of Chatillon-Commentry and St. Etienne each submitted 16-centimeter (6.3 inch) Harveyed plates, and M. Schneider, of Le Creuzot, furnished a 16-centimeter (6.3 inch) plate, face-hardened by his gas process. Against each of these plates, a 138.6-millimeter (5.46-inch) projectile, weighing 66 pounds, was fired with a striking velocity of 2,313 foot seconds, and, in addition, the Chatillon-Commentry plate received the blow of a 100-pound projectile from a 164.7-milimeter (6.46-inch) gun, with a velocity of 2,198 foot seconds. The result showed the mean valuation of the plates as compared with untreated steel plates to be as follows: Chatillon-Commentry, 1.4, steel being, 1; St. Etienne, 1.37; Le Creuzot, 1.36.

All the trials carried out in France during the past year seem to demonstrate the superior quality of the French special steels, as well as the marked advantages obtained by the employment of the Harvey process.

GERMANY.

Herr Krupp exhibited at the Columbian Exposition at Chicago some compound plates, and also some plates of nickel-steel, one of which was face-hardened by a process analogous to the Harvey process. One of the nickel-steel plates, measuring 10 feet 9.6 inches by 8 feet 4.8 inches by 11.81 inches and weighing 20 tons, had been attacked, on November 25, 1892, by 4 steel and 1 chilled iron projectiles from a 28-centimeter

(11.02 inch) gun. The blows delivered were with a projectile weighing 512.3 pounds and a striking velocity of 1,554 foot seconds, which gave a calculated perforation of 12.9 of steel, or considerably more than a match for the plate. The plate made an excellent showing, both as to resistance to perforation and cracking. The steel projectiles were recovered uninjured, but the chilled shot was broken in the plate. The nickel-steel plate with hardened face measured 8 by 6 feet by 10.23 inches and weighed 9 tons. This was attacked, on March 13, 1893, by steel projectiles fired from both a 15-centimeter (5.9-inch) and a 21-centimeter (8.27-inch) gun.

The former fired 3 rounds, with 1,886, 2,000, and 2,130 foot seconds velocity. The last, with a projectile weighing 112.4, had a calculated perforation through iron, by Krupp's formula, of 17.46. Two rounds were fired from the 8.27-inch gun, one with a steel projectile weighing 209.6 pounds and 1,727.7 foot seconds velocity, the other weighing 307.5 pounds and a velocity of 1,824.5 foot seconds, having a calculated perforation of 19 inches of iron by Krupp's formula. The first projectile made a decided bulge and tear at the rear surface, while the second one broke in the plate.

HOLLAND.

In August last various manufacturers of armor submitted plates for competitive tests, by invitation of the Dutch Government, preliminary to awarding the contract for the armor of three vessels now constructing in Holland. The trials took place at Helder, on the Island of Tesel, in the north of Holland, on the 23d and 24th of August. The competing firms were C. Cammell & Co., John Brown & Co., and Vickers & Co., each having nickel-steel Harveyed plates; Krupp, Schneider & Co., who furnished nickel-steel plates treated by their own peculiar face-hardening processes, and the St. Chamond establishment, represented by a homogeneous plate of special steel (acier special). The plates were supposed to be 6.56 feet by 4.92 feet by 5.9 inches, but on measuring them it was discovered that the plates furnished by Messrs. Cammell & Vickers were the only ones which did not exceed the correct thickness by some millimeters, in the case of the Creuzot plate the excess being 6 millimeters (0.24 inch). The gun used was a Krupp 12-centimeter (4.72-inch) B. L., 35 calibers long. The projectiles were of Krupp's special armor-piercing type, weighing 57.3 pounds each. The range was 80 meters (262.5 feet), and 5 shots were fired at each plate with the following velocities: First, 1,443 foot seconds; second, 1,574; third, 1,640; fourth, 1,772; fifth, 1,880 foot seconds. The results are summarized as follows:

Plate of Vickers & Co.:

First shot: The projectile penetrated 6.89 inches, and rebounded 77.4 feet, practically intact, but somewhat set up. The greatest diameter

of the orifice in the plate was 11.6 centimeters, and there was considerable flaking and scaling around it.

Second shot: The projectile penetrated 8.07 inches, the point just touching the backing, was thrown back about 46 feet in front of the target, and was recovered intact, but somewhat set up. The maximum diameter of the hole was 4.72 inches, and the edges were flaked and scaled.

Third shot: The projectile was broken up, a portion remaining in the plate, but falling out after the next shot, which showed the amount of penetration to be 2.4 inches. The edges of the orifice were somewhat scaled.

Fourth shot: The projectile was broken up, a portion remaining in the plate. The edges of the point of impact were scaled.

Fifth shot: The projectile was broken up and deformed, a portion resting in the plate. The plate was split into three pieces.

Plate of C. Cammell & Co.:

First shot: The projectile penetrated 6.89 inches and was thrown back to about 66 feet in front of the target. The projectile was intact but somewhat set up. There was considerable scaling around the point of impact.

Second shot: The projectile broke up, the head remaining in the plate and turning to the right. The base of the shell was recovered about 24.6 feet in front of the target. There was some bulging and scaling around the orifice. The maximum diameter of the orifice was 4.92 inches.

Third shot: The projectile perforated the plate and backing, and was recovered 591 feet in rear of target. The projectile was set up and the ogival head showed several fine cracks. The plate was scaled around the point of impact.

Fourth shot: The projectile perforated the plate and backing, and was recovered about 2,181 yards in rear of the target. The projectile was split lengthwise and was considerably set up. The diameter of the orifice was 4.6 inches, and there was considerable scaling.

Fifth shot: The projectile perforated the target. The portion of the second projectile which remained in the plate was pushed aside and broken up. The backing was badly damaged.

St. Chamond plate:

First shot: The projectile penetrated 6.4 inches and was thrown back about 78.7 feet in front. The projectile though set up was intact. The plate was bent and torn around the point of impact. The diameter of the hole was about 6.3 inches.

Second shot: The projectile penetrated until the point just pierced the rear surface of the plate, disclosing the backing, and was thrown back about 102 feet. The projectile was intact though somewhat set up. The greatest diameter of the hole was 4.72 inches and the border was raised about 1.28 inches.

Third shot: The projectile penetrated until the point made a hole in the rear surface of the plate about 1.18 inches in diameter, and was thrown back 95 feet. It remained intact but set up. The diameter of the hole was 4.68 inches and the edge was raised to 1.37 inches.

Fourth shot: The projectile perforated the plate and backing and broke up, the base remaining plugged in the plate. The edge of the hole was raised 3.93 inches.

Fifth shot: The projectile passed through the plate and backing and broke up, the base remaining in the plate about 6.39 inches from the front surface, and being broken in 4 pieces. The diameter of the hole was 4.98 inches, while the edges were bulged to about 1.48 inches. The head of No. 4 projectile fell inside the target.

Krupp plate:

The first shot penetrated 6.95 inches and was thrown back 92 feet in front, uninjured. There was a fringe and several fine cracks around edge of orifice. The diameter of the hole near the surface was about 6.7 inches.

The second shot penetrated 8.7 inches, the point making a small hole in the rear face disclosing the wood backing, and broke in two. The head was recovered about 36 feet and the body about 82 feet in front of the target. The maximum diameter of the hole was 4.65 inches, and the height of the fringe 1.3 inches.

The third shot perforated the plate and backing, and was broken up. The head was recovered about 115 feet in rear of the target, while the body was found inside the target. The maximum diameter of the orifice was 4.6 inches, and the height of the surrounding fringe was 1.33 inches.

The fourth shot perforated the target and was recovered about 1,640 yards in rear. The projectile was mutilated and set up. The diameter of the hole was 4.6 inches, and the height of the surrounding fringe 1.34 inches.

The fifth shot perforated the target and fell at about 2,187 yards in rear. The diameter of the orifice was 4.7 inches, and the height of the fringe 1.38 inches.

Plate of Schneider & Co.:

The first projectile penetrated 7.3 inches and was thrown back to 32.8 feet in front of the target. It was intact, though somewhat set up. There was a small crack at the bottom of the orifice about 0.16 inch long and 0.039 inch wide.

The second shot penetrated a short distance and broke up, the head remaining embedded in the plate. The base of interior cone was about level with the face of the plate.

The third shot perforated the target and was recovered about 600 feet in rear of the target uninjured. The diameter of the hole at the surface of the plate was 4.33 inches. The plate was bulged and cracked around the orifice.

PLATE OF VICKERS SONS & CO.

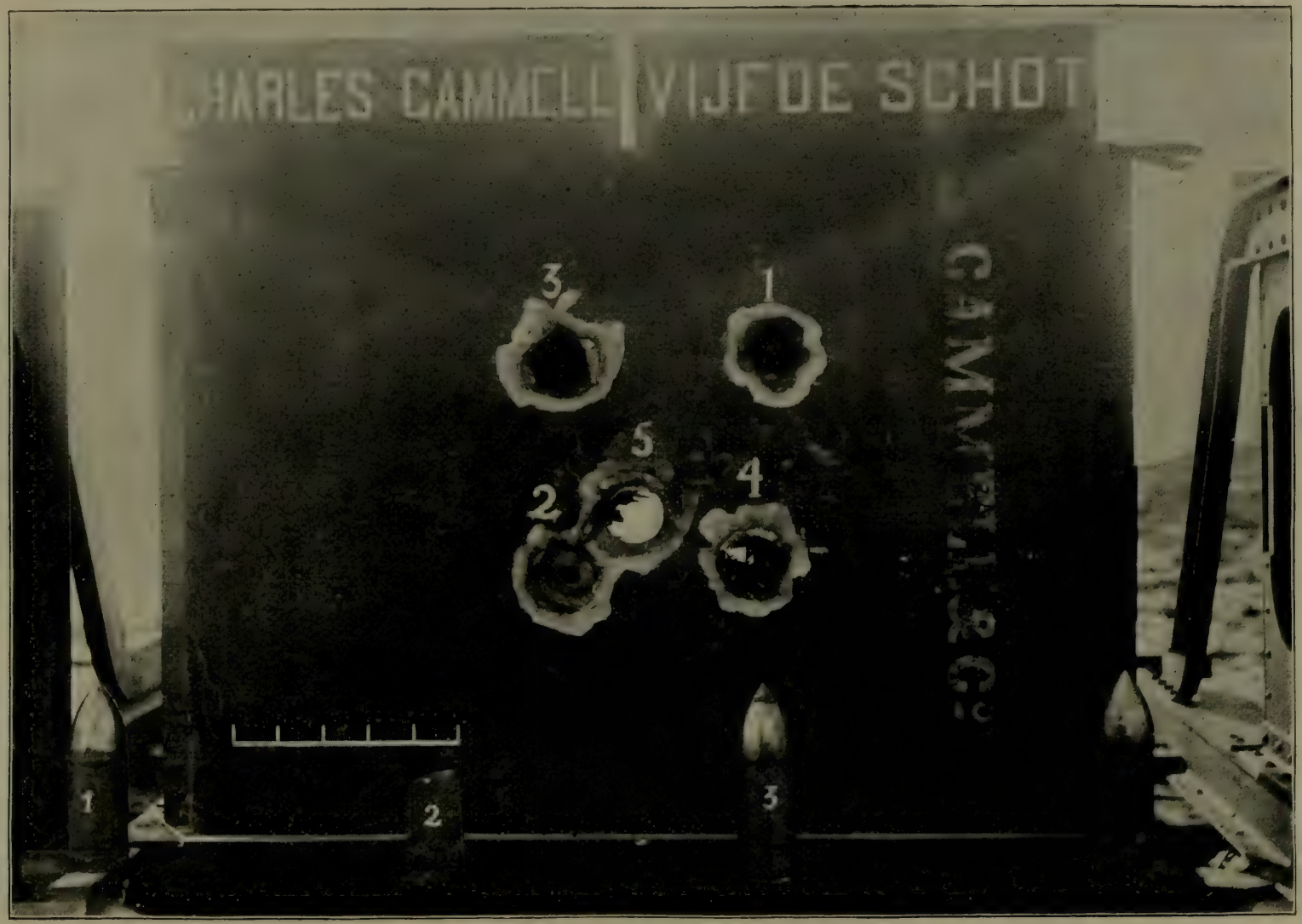
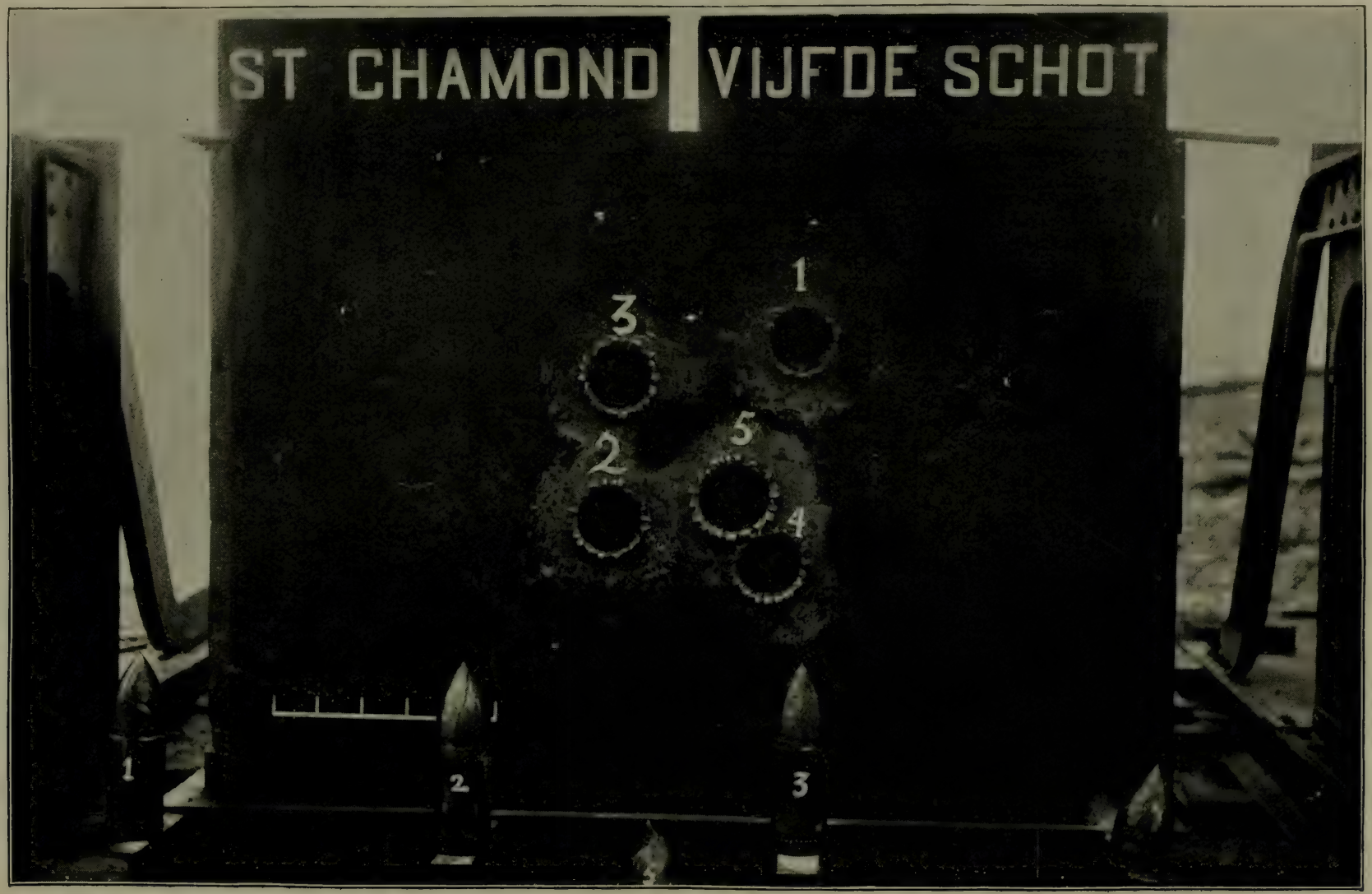
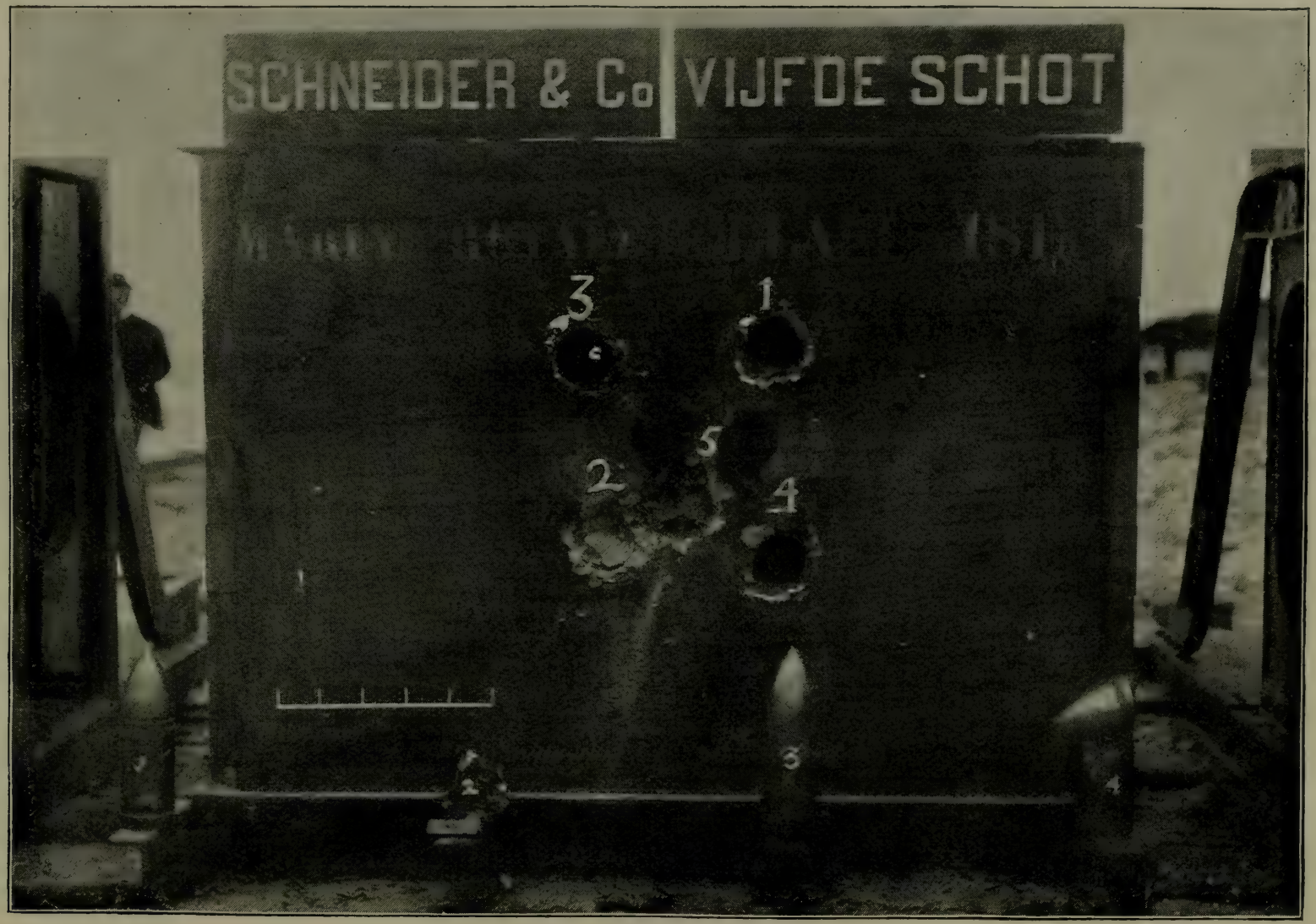


PLATE OF CHARLES CAMMELL & CO.



ST. CHAMOND PLATE.

KRUPP PLATE.



SCHNEIDER (LE CREUSOT) PLATE.

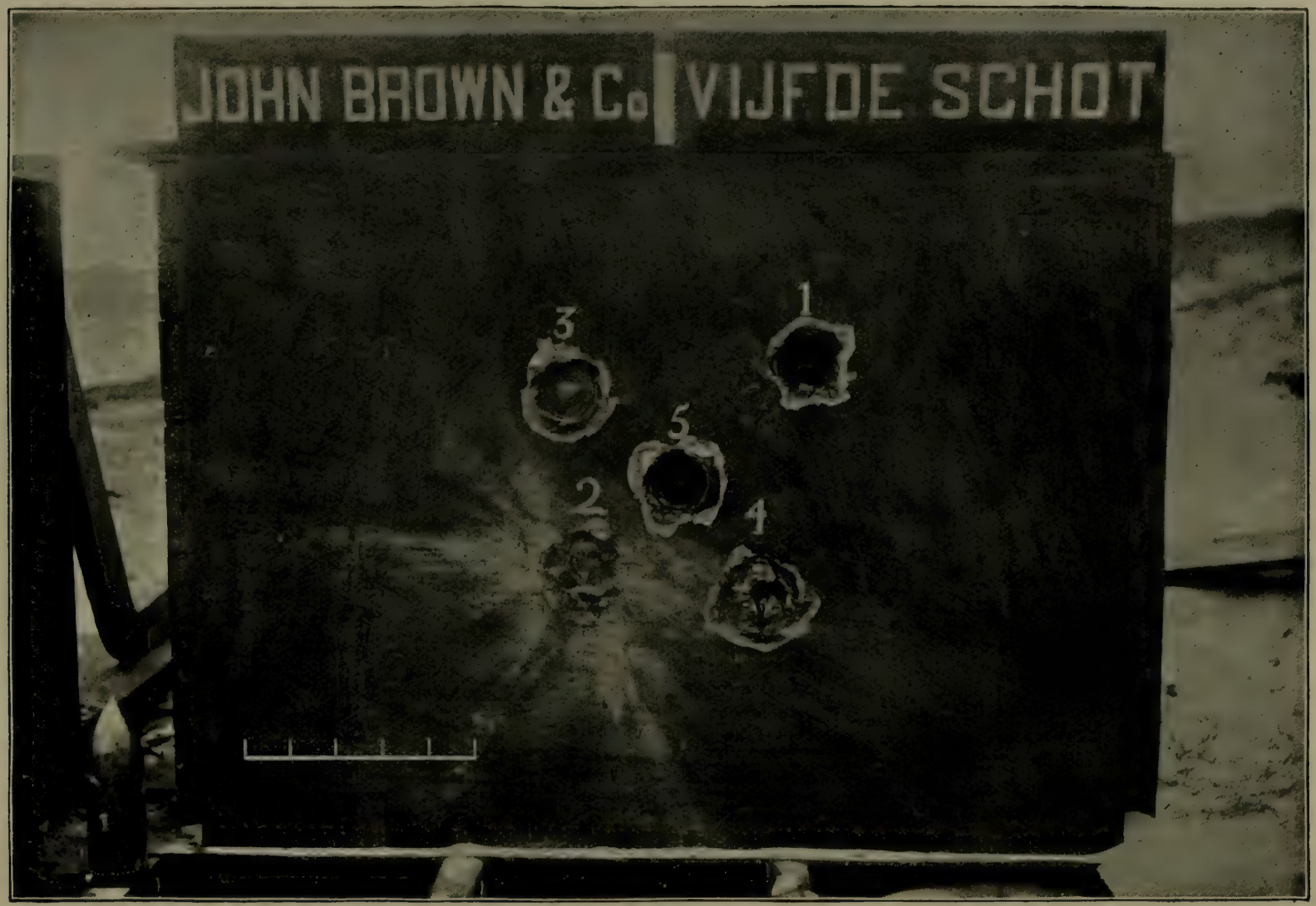
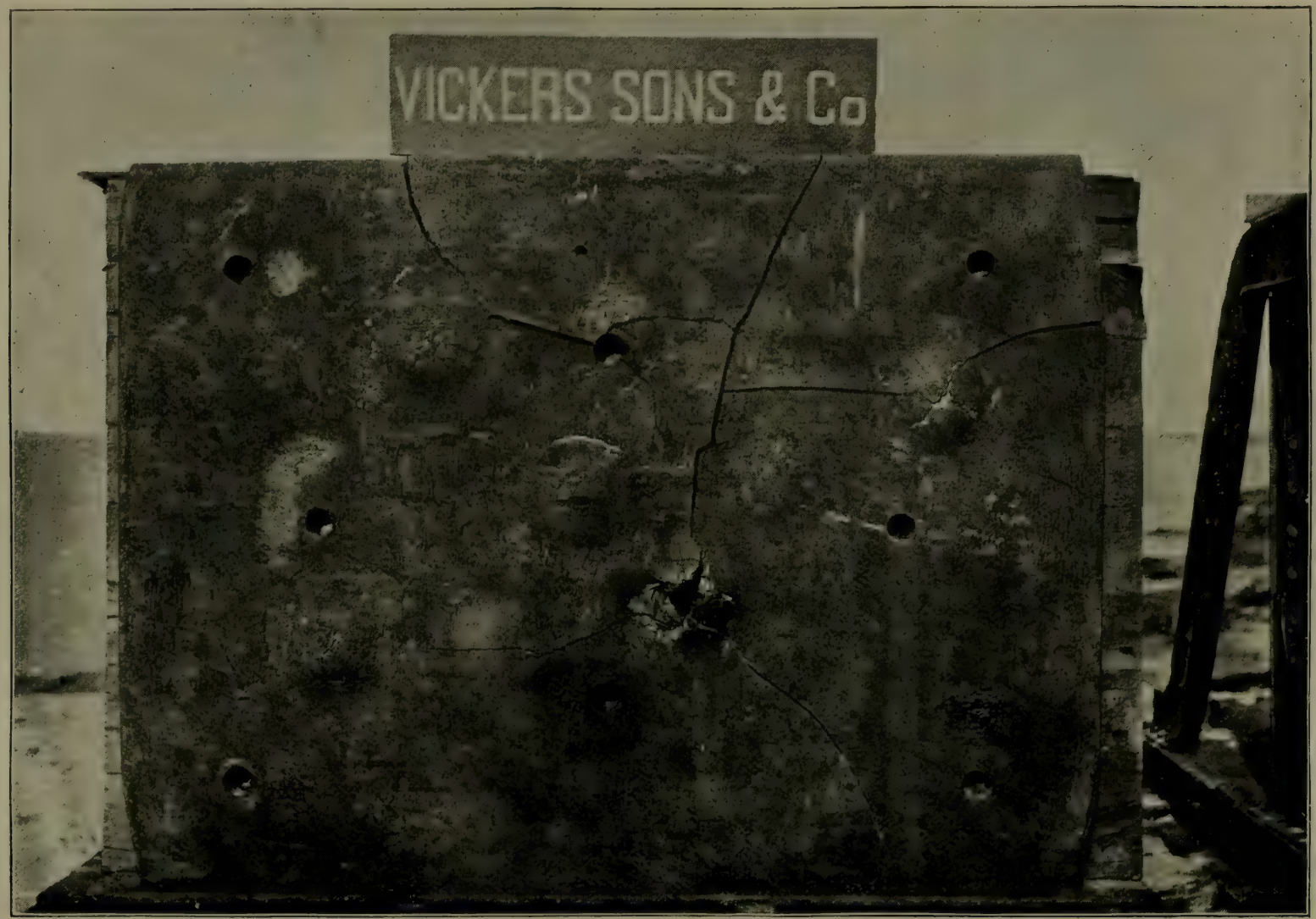


PLATE OF JOHN BROWN & CO.



REAR VIEW OF PLATE OF VICKERS SONS & CO.

BACK OF A TARGET AFTER TRIAL.

The fourth shot passed entirely through the target and broke up. The head of the projectile was recovered about 1,530 yards in rear of the target and the body at 547 yards in rear. The diameter of the hole at the surface of the plate was 4.53 inches. The part of No. 2 shot which had remained in the plate fell out.

The fifth shot penetrated a short distance and broke up, a portion remaining in the plate.

Plate of J. Brown & Co.:

The first shot penetrated 6.93 inches and was thrown back 45.9 feet in front of plate. The projectile was intact, but somewhat set up. The orifice at point of impact was jagged.

The second projectile penetrated a short distance and broke up, the head remaining embedded in the plate.

The third shot penetrated nearly through the plate and backing, the base being 0.59 inch inside the face of the plate; no cracks in plate. The penetration was about 16.2 inches. The edge of the hole was ragged and scaled.

The fourth shot penetrated about 6.3 inches and broke up, the head remaining in the plate and projecting in rear. The plate was considerably damaged around the point of impact.

The fifth projectile perforated the entire target. The diameter of the hole in the plate near the surface was 4.73 inches, and the edges were scaled.

At the close of the trials the bolts of all the plates were found in good condition, and the only plate which showed any serious cracks was that of Vickers & Co. Some days after the end of these trials, at the request of the manufacturers, two additional shots were fired at the plate of Vickers & Co., with velocities of 1,444 foot seconds. The first one penetrated 6.53 inches and broke up, and the second 7.09 inches and rebounded intact, but set up.

Some additional cracks were developed, and the pieces of plate were somewhat more displaced, but the plate resisted the attack admirably. It will be noticed that all three of the shots fired at this plate at velocities above 1,575 foot seconds broke up, viz, No. 3 at 1,640 foot seconds; No. 4 at 1,772 foot seconds, and No. 5 at 1,880 foot seconds, while all the projectiles fired at and below 1,575 foot seconds rebounded almost uninjured.

The photograph of the back of the Vickers plate is taken after the additional shots, and shows how little additional damage resulted, and that the plate would still afford excellent protection to the side of a ship. The target was constructed with a covering plate in rear, and some idea of the effect of the projectiles on a ship was obtained from their action on such a target. The back view of one of the targets after the trial shows how the plate at back of the target was damaged.

RUSSIA.

Some remarkable results were obtained at a trial of Harveyed armor plates on June 28 last, at the Ochta Polygon.

Of the three plates tried, one was furnished by Messrs. Cammell & Co., and was 8 feet square by 6 inches in thickness, while the other two were supplied by the firm of John Brown & Co., one being of the same dimensions as the Cammell plate and the other a curved plate 8 feet square by 10 inches in thickness. A 6-inch Aboukoff gun, 45 calibers long, was used throughout the trial. The projectiles were of two kinds, one being the ordinary Holtzer shell, made at the Putiloff works, and the other a similar shell with a Russian improvement, the secret of which is jealously guarded, but which is believed to be a soft steel cap held in place over the hardened point of the shell by magnetism. Four of these projectiles were fired at each of the 6 inch plates with velocities of about 1,850 foot seconds each, and at angles varying from the normal to 25 degrees, and four against the 10-inch plate with velocities of about 2,400 foot seconds each. Owing to the curvature of the latter plate, the projectiles struck at angles of from 8 to 10 degrees. The first three shots passed through the Brown 6-inch plate intact, but the fourth, though it perforated the plate, was broken up. The shot striking normally perforated the Cammell plate uninjured, and the one striking at 15 degrees passed through, but was broken up. The shot striking at an angle of 20 degrees penetrated 3.3 inches and was pulverized, and the same was the case with the fourth shot. A couple of Holtzer shells, without the secret improvement, were then fired at each plate, one normally and the other obliquely. The normally striking projectiles penetrated the plates but not the backing, whilst those striking obliquely failed to get through.

The curved plate was perforated by the improved projectiles, but resisted the ordinary Holtzer shell.

Further trials at greater angles of obliquity are soon to be made.

The results seem to demonstrate the superior quality of the Holtzer shells made at Putiloff and also the remarkable success of the secret improvement which has been made in Russia.

IV.

NOTES ON SMALL ARMS.

By Lieut. LINCOLN KARMANY, U. S. Marine Corps,
Staff Intelligence Officer.

SMALL-CALIBER RIFLES

CALIBER AND BALLISTICS.

The introduction of the strong, yet slow, powders, called "smokeless," made practicable a radical reduction in the caliber of the infantry arm, the advantages of such a reduction being already understood. France led the way in 1886, and the most advanced step in this direction was recently taken by the adoption of a caliber of 6 millimeters (.236-inch) for our Navy and Marine Corps. The opinion of experts seems to be that until a heavier metal for bullets can be found at a moderate cost the smallest effective caliber is .236-inch, or perhaps 5.8 millimeters (.228-inch). It is believed that with the materials at present available a bullet much below .236-inch in caliber can not be depended upon, even at a very high velocity, to stop a horse at short range, as in repelling a charge, nor will it give the desired trajectory at long range.

To secure satisfactory ballistic results a sectional density of at least 3,000 grains per square inch is aimed at. This calls for a bullet for the .256 or .236-inch more than 5 calibers long, and the rapid twist and high velocity necessary to keep it end on during its flight subject the barrel to a high pressure, which increases rapidly as the caliber is reduced Although a lighter and consequently proportionally shorter projectile gives, with the same pressure, a higher velocity and flatter trajectory at short range, the depth of danger zone and penetrative power decrease too rapidly as the range increases, this depth of danger zone at long range being considered of great importance in operations on shore.

Much difficulty is experienced in obtaining powders suitable for the smaller calibers, each of which requires a special kind. One which in the French .315-inch rifle gives an initial velocity of 2,099 feet per second with a maximum pressure of 34,135 pounds per square inch,

will, in the .30-inch, only give this velocity with a pressure of 45,513 pounds per square inch. Powders suitable for different calibers may have the same chemical composition, and differ only in thickness and density, which are regulated by pressure and rolling. Extensive experiments with the very small calibers have been delayed by the want of suitable powders. It may be taken for granted, however, that the powder can be produced and this difficulty overcome.

The degree to which the advantage of improved ballistics has been realized is referred to hereafter. The other principal advantage in reducing calibers is that of decreased weight of ammunition, enabling a greater number of cartridges to be carried. For the .256-inch 200 cartridges weigh, with clips, only 10.5 pounds, and for the .236-inch the weight will be still less. But the saving in weight below the latter caliber is inconsiderable, the proportionally longer bullet weighing nearly as much, and the cartridge case being thicker and heavier to withstand the higher pressure. Attempts to reduce the pressure by considerably increasing the air space in the shell give promising results, and although the stricture at the neck of the shell tends to reduce the initial velocity, it is believed to be practicable with some powders. There is reason to believe also that the presence of any small foreign substance in the bore of a 5-millimeter (.197-inch) rifle, such as a spot of rust which might form during a night, would, when fired with steel-clad bullet, cause the barrel to swell or burst. As regards weight of piece there is no saving below .236-inch, the walls of the barrel having to be made thicker to withstand higher pressures.

For purposes of comparison as regards ballistics and weight of ammunition the various calibers adopted and in use may be divided into four classes and represented by calibers of 8, 7.65, 7, and 6.5 millimeters (.315, .301, .276, and .256-inch), to which is added the Springfield .45-inch.

The following table gives approximately some service data of these rifles:

Caliber.	Springfield .45-inch.*	8-millimeter (.315-inch).	7.65-millimeter (.301-inch).	7-millimeter (.276-inch).	6.5-millimeter (.256-inch).
Initial velocity....foot seconds..	1,360	1,890 to 2,070	1,970 to 2,140	2,300	2,300 to 2,400
Height of vertex of 550-yard trajectory above line of sight, ...inches..	132	59 to 57	57 to 55	42	40
Depth of danger zone at 1,100 yards, height of target 5 feet 7 inches.....yards..	22	37	38	40	42
Depth of danger zone at 2,200 yards.....yards..	.....	8	8	8	8
Weight of 200 cartridges with clips.....pounds..	20	13.6	12.6	11.5	10.5

* With 500-grain bullet.

In experimental firing the Navy .236-inch has given an initial velocity of 2,450 foot seconds, an ordinate for 500 yards of 2.6 feet, while it is expected that the weight of 200 cartridges with clips (if adopted) will be 9.8 pounds. The maximum continuous dangerous space for infantry standing (height 5 feet 10 inches) is, for the .315-inch 445 yards, and for the .256-inch 540 yards, firing height 4 feet 10 inches. From experimental firing thus far at home and abroad there is reason to believe that the .236-inch will increase this distance to 600 yards. As regards penetration, that of the .315-inch bullet is 21 inches in beech block at a distance of 15 yards; that of the .256-inch, 27 inches. The .236-inch bullet has penetrated sixty 1-inch pine boards. The accuracy of fire does not materially differ in these calibers, though the smaller calibers show greater accuracy at the shorter ranges. At 2,200 yards the remaining velocities are, for the .315-inch, 530 feet; for the .256-inch, 650 feet. The superiority of the .256 and .236-inch pieces over those of larger caliber is therefore evident both from a tactical and ballistic point of view.

BREECH CLOSURE.

The sliding-bolt system of breech closure is now universally used, and in all models adopted since 1890 the bolt handle turns down in closing, the "straight pull" being used only in the Swiss Schmidt and the Austrian Mannlicher (rifle and carbine). This system, designed that the breech mechanism may be operated with the piece at the shoulder, does not seem adapted to the very small calibers and smokeless powder. After a number of fires it requires considerable effort to operate while at the shoulder, and the man generally falls back on bringing it down after each fire, this being especially the case with the Austrian rifle. Besides, the high pressures call for locking lugs with large bearing surface, of equal strength and symmetrically placed close to the end of the bolthead, requirements difficult to fulfill with the straight pull. When, as in the Austrian and Swiss rifles, the tenons are considerably removed from the end of the bolthead, the bolt vibrates, and finally sets up or works loose. For strength and position of locking lugs the Mauser breech bolt is to be recommended.

It is well known that in firing several rounds at a target the hits are better grouped when the eyes are not removed from the target between fires; this is secured for the arm with bolt of double movement by packet or multiple loading, and probably this system allows of sufficient rapidity of fire consistent with effectiveness and the present state of ammunition supply. Should the weight of ammunition be further greatly reduced, as by the adoption of some such propelling agent as liquified gas, making the heavy metallic case unnecessary, and it be considered desirable to quicken the fire, it would perhaps best be accomplished by adopting a semi-automatic rifle, to be used ordinarily as a multiple loader until the emergency arose requiring great rapidity of fire, when the semi-automatic mechanism could be

thrown into action. The piece would then be prepared for another fire by the force of recoil, requiring, however, the trigger to be pulled and then released for each discharge, and the piece to be brought down from the shoulder and recharged after exhausting a packet.

The straight pull, however, lessens the difficulties of extraction. If the extractor turns with the bolt it often involves a channel in the chamber at the base of the shell, thus weakening it; shells have also been cut by the extractor nib, rendering them defective. The first difficulty is overcome in the Belgian Mauser by sinking the entire extractor in the bolt. It is best avoided, however, by arranging that the extractor remains fixed while the bolt turns down, as in the latest models of both Mauser and Mannlicher, though this result is attained in different ways. The Mannlicher has a movable bolthead bearing the extractor, which, however, separates the locking lugs from the end of the bolt by nearly a half-inch, and is objectionable for this reason. The Spanish Mauser, M 93, has an improved extractor working on a ring well to the rear of the bolthead, the ring and extractor remaining fixed as the bolt handle turns down. This feature, and indeed the entire breech closure of this rifle, commend themselves for simplicity and efficiency. It is thought, however, that the method of compressing the spiral spring used in other arms, as in the Mannlicher, by inclined surfaces working together so that the spring is compressed to the firing position by turning the bolt handle up and down, is preferable to that employed in the Mauser, principally a straight push in moving the bolt forward to close the breech. A number of men unfamiliar with the piece have been observed, in operating the Argentine Mauser, to hesitate on feeling this resistance to closing, thinking there was a jam; at all events it calls for unnecessary exertion of which the firer should be relieved. For protection against escaping gas through the locking-lug channels in case of defective shells, filling lugs are provided in some of the recent models, those on the Spanish Mauser being placed well to the rear, on the sleeve which carries the safety attachment.

For preventing double feed by forward movement the plan adopted in the later Mauser and Mannlicher arms, of having the cartridge gripped by the extractor as soon as it rises from the magazine, is very simple. The shell then follows any forward or backward movement of the bolt, and if the ejector is so placed that the shell is thrown out before the bolthead reaches a position far enough to the rear that it would take against the base of the next shell in the magazine, there can be no jamming of the empty shell with the next cartridge.

In the latest models there is no halfcock, as we understand the term. The piece is intended to be cocked only by working the bolt handle, and the firing pin lowered only by pulling the trigger. There is, however, a safety-locking attachment, turned by the thumb of the right hand, to lock both bolt and trigger when the piece is loaded and cocked,

allowing it to be carried in this condition with safety. An element of danger to others, the "easing down" of the firing pin, is eliminated. The bolt shows at a considerable distance whether "safe" or not, while for the man handling the arm, after becoming familiar with it, the "feel" of the safety catch will be sufficient. When not locked the trigger may, in the case of some rifles, as, for instance, the Argentine Mauser, be pulled and the firing pin released even when the bolt handle is not completely turned down, but the pin does not reach the primer until the bolt is down, being held by a lug or shoulder engaging on a helicoidal ramp on the cylinder, the same arrangement which operates to withdraw the firing pin from the primer during the upward movement of the bolt handle when opening the breech after firing. In others, as the Austrian carbine (p. 118, No. XI) and Spanish Mauser (p. 172, this volume), it is made impossible to pull the trigger without having the bolt completely turned down.

REPEATING MECHANISM.

The question of kind and position of magazine has already been settled in favor of the box under the receiver, France, although still using the tubular on its rifle, having pronounced against it by the subsequent adoption of the Berthier carbine (p. 121, No. XI). The box magazine is simpler, more quickly and easily charged, and the balance of the piece is not altered to such an extent as the magazine is drawn upon. With the greatly lessened weight of ammunition for the very small calibers, the magazine arm proper, used ordinarily as a single loader with a magazine in reserve, is giving place to the multiple loader, for which all cartridges are put up in pockets, generally of 5, which are inserted at once and in about the same time taken to charge with a single cartridge. Considering the large number of cartridges (about 200) which may be taken into action it is believed that the cut-off is no longer called for and is even pernicious, introducing as it does a complication in loading and firing. Ritter von Mannlicher, whose rifles are in such general use, states that none of his arms adopted have it. With the multiple loader there is but one kind of loading and firing; besides it is well to consider the moral effect on the average man should he exhaust his magazine, which he has come to look upon as a reserve, before the emergency calling for rapid fire has passed, and be compelled to fall back on single loading. The English and French magazines may be emptied in about 20 seconds, rapid aimed fire, and the new U.S. Army in 10, after which single fire would have to be resorted to. The English magazine is charged cartridge by cartridge, but it is believed a charger will be adopted. The French, realizing their shortcoming in this respect, have been experimenting with a charger. The Swiss magazine, holding 12 cartridges, is charged by 2 packets of 6 each. Thus abroad, for rifles having a magazine in reserve, a charger is considered desirable and a considerable number of cartridges in the magazine.

An objection to multiple loading is the additional weight of the clip, which in the later models of both Mannlicher and Mauser is about 150 grains. If 200 cartridges are carried this additional weight is only that of about fifteen .236-inch cartridges and may possibly be still further reduced.

As regards the method of charging with packet, whether to enter the charger with the cartridges as in the Mannlicher, the bottom of the magazine being cut away to allow it to drop out when empty, or, as in the Mauser, to strip the cartridges off from the clip into the magazine, the clip dropping off when the bolt is first shoved forward, the former plan seems preferable, as the sides of the charger, when in the magazine, save the latter, the upper lips serving as spring clips or distributors. Otherwise, the spring sides of the magazine are likely to suffer from long use, or in attempting to force more cartridges in when the magazine is full; this trouble has been experienced in the Lee-Metford. The Mauser clip, as used in the Belgian and Argentine models, a mere strip, holding the base only of the shell, does not make a firm packet for handling and is much improved upon in the Spanish model, holding both base and sides of the cartridges. The charger should admit of being entered either side first, and the magazine should have a feed spoon, allowing a single cartridge to be used, if necessary, when the magazine is empty. This is not the case with the Mannlicher model 1892, but it is practicable with the Mannlicher system, as instanced by the Berthier carbine.

Any leading manufacturer will provide a cut-off if desired, although it is not a feature of the latest service arms except in our country. For this purpose the method proposed by both Mauser and Mannlicher appears preferable. By means of a button or small lever beside the receiver the magazine may be lowered the fraction of an inch, so that the bolthead in moving forward passes over the upper cartridge instead of taking it along, thus shoving home the single one laid on top, the lever possessing the advantage of having its position show at a greater distance.

SIGHTS.

The front sight retains its general form, although considerably stronger than the present Springfield sight, which is not adapted to use on board ship or in boats. The flat trajectory of the .256 or .236-inch rifle makes it possible to greatly simplify the rear sight. We find that with the latest models adopted the simple folding sight bar with sliding leaf is used, and there is no lateral adjustment to allow for wind. The block sight, leaf down, is fixed at 400 or 450 meters (437 or 547 yards), and the face of the bar marked for each 100 meters from 600 to 2,000 or 2,100. Following this plan we would have for the .236-inch a fixed block sight for say 500 yards, and begin the graduations of the leaf at 600. The trajectory with the fixed sight would rise to about 2.5 feet above the line of sight, which would give a continuous danger-

ous space against infantry standing, the piece fired standing. Using this sight when the object aimed at is 300 yards distant would cause the bullet to "fly high" about 2.5 feet, most of which, if not all, would probably be neutralized by fixing the bayonet. This depends on the weight of bayonet and balance of the piece, but for the Lee-Metford amounts to just 2.5 feet at 350 yards with 500-yard sight, and for this reason 350 yards is the distance laid down for fixing bayonet. The remaining error, then, within this distance would be little more than a foot. Should it be considered desirable to place in the hands of a few picked men a special sight for sharpshooting, a detachable telescopic sight could be adjusted to the stocks of such pieces.

BARREL, MOUNTING, ETC.

Crucible steel, forged, is most generally used for gun barrels. The twist varies from 1 turn in 9.5 inches in the .315-inch to 1 in 6.5 inches in the .236-inch, the more rapid twist being necessary to keep the proportionally longer bullet end on in its flight. Four or 6 grooves are generally cut, and in the smaller calibers to a depth of only three or four thousandths of an inch. The average length of barrel is about 30 inches.

The metallic tube envelope is suppressed in the later models. It was fitted for the purpose of holding the barrel while allowing it to vibrate and expand without constraint. To this end the bands and sight masses were secured to the envelope, which also allowed the piece to be handled when the barrel was hot from rapid firing. The inventor has abandoned it, however, having found that the metal does not expand perceptibly throughout the entire length of the barrel, and he has placed the lower band at the point where this expansion practically ceases, allowing, however, for about 5 millimeters (0.197-inch) lengthening of the part in rear of it with little friction (Mauser, M/93). As a hand guard the envelope is of doubtful advantage; if it delays heating it also delays cooling, and a wooden hand guard answers better.

Although in all the modern pieces except those of England and France the stock and butt are in one, there are good reasons for having them separate. Greater strength can be given the arm in this way, and it allows of a better choice of wood, which can also be more readily shaped. A short piece, again, is not so apt to warp, a very important matter with the slender barrels used. To prevent warping the use of some such material as papier-maché has been proposed. The Swiss stock, enveloping the barrel completely as far forward as the front sight, is preferred by some experts to avoid the difficulty in aiming over a hot barrel.

The "pull-through" or cleaning cord has been found to wear away the metal about the muzzle after long use; a steel rod, with wooden envelope to protect the lands, is probably better.

Everywhere is the knife or sword bayonet used, except in France and Russia. Although its use as a weapon hereafter will be rare, its moral effect is still great, and it is considered necessary. The short knife, with blade 8 to 12 inches in length, most generally employed, is light, does not touch the ground when kneeling, and is useful as a knife in campaigning, while it does not influence the trajectory so much as the heavy one. It should be fixed underneath the barrel, so as not to cause lateral deviation of the bullet.

AMMUNITION.

The so-called smokeless powders are now in general use in service rifles, resulting, with the reduced caliber, in greatly improved ballistics and lighter ammunition. Combustible cartridge cases, which would make extraction unnecessary and still further lighten ammunition, have not proved a success, not possessing sufficient strength and rigidity to endure transportation and to hold the primer against the blow of the firing pin; the cavity of the pin becomes clogged, and there is difficulty in securing perfect obturation to prevent spitting. Experiments with celluloid cases show that they keep badly, are easily broken, and the combustion is incomplete. Aluminum has also proved unsatisfactory, being too soft and losing its tenacity as the temperature is raised; the base cups frequently breaks away and the cylinder is crushed.

Regarding the question of rimmed or grooved cases, although many authorities still prefer the former, the latter are believed to be better, especially for multiple loading, as regards size and shape of packet and consequent advantages in loading and packing. They allow a perfectly symmetrical and at the same time compact packet, which may be introduced either side first. In seeking for ammunition for their .256-inch rifle, the Italian authorities, realizing the advantage, experimented extensively and finally adopted a grooved shell. The difficulty of extraction was overcome long ago, but it was held against the rimless shell that the slope at the neck could not be depended upon to fix the primer in its proper position to receive the blow of the firing pin, resulting in miss-fires. This is overcome by more care in manufacture, and by having the shell gripped by the extractor and held securely against the blow. The difficulty most felt was that of preventing the shell from giving where weakened by the groove, loosening the primer which, when the breech was opened, sometimes dropped into the mechanism of the magazine. This may be overcome by making the base solid to a point just forward of the groove. That the objections to the rimless shell have been overcome is shown by the fact that they are used in the Mannlicher automatic rifle, where a failure to work properly would jam the piece, and they are also used in the latest Mauser, M/93.

The core of the bullets used is of lead, hardened by from 5 to 8 per cent of tin or antimony, with an envelope to keep it in shape while

taking the rifling, and prevent it stripping; the envelope also increases the penetration, and is a protection against rust. This envelope is of steel, mailleschort (alloy of copper, zinc, and nickel), or nickel. Simple steel is being abandoned as causing too much wear of the lands and being liable to rust, the envelope finding most favor at present being of steel plated with a nickel-copper alloy. For the Roumanian Mannlicher bullet thin plates of steel and this alloy are rolled together.

Remarkable results with the Hebler tubular bullet have been published, the channel through which is about two-fifths of its diameter, the idea being to thus lessen the resistance of the air. Though with a bullet lightened in this way a flatter trajectory would be obtained at short range, it is believed that the velocity and penetration claimed for it at long range are the result of calculation and not of actual experiment. Trials of such a bullet in this country showed that at 1,000 yards it fell considerably below the solid bullet of the same caliber, using the same charge. The inventor himself says that it is not practicable with leaden core and steel envelope, on account of deformation, but claims great results with an all-steel bullet of the same shape. Its low specific gravity is, however, very much against it.

WOUNDS.

Experiments abroad with bullets of calibers .315 to .236-inch, with full charges, for effect on bones and tissue of the human body and that of horses, lead to conclusions similar to those published in the Journal of the Royal United Service Institution, January 15, 1894, by Veterinary Capt. F. Smith, British army, and may be summarized as follows:

The experiments resolve themselves into two groups, viz, those from 50 to 200 yards and those from 300 to 2,000 yards.

The first group comprises those injuries which, when a bone is struck, resemble in appearance those of an explosive character; the part is always pounded, fragments are frequently carried out through the wound of exit, which is commonly converted into a gaping orifice; the muscles are pulped and, in fact, the limb mangled and damaged beyond repair.

If the bullet simply passes through muscle it practically creates no damage of any importance unless it strikes an artery, which, large or small, are cut as with a knife, causing hemorrhage; but because of the small size of the bullet the blood vessels and nerves stand a better chance of escape than they did with the larger bullet. If a savage were hit in the fleshy part of the thigh with the small-caliber bullet it could not be expected to have any stopping effect on him unless the main artery of the limb were opened, and even in this condition he could travel some little distance before falling, but let that man be hit on any of the long bones of the leg and his progress is at an end. On the other hand, if he were hit in the upper extremity (speaking of a savage) there would probably be nothing to stop him in a smashed

shoulder or a pulped elbow, because, like the horse, he apparently does not suffer from shock, and he still has the use of a pair of legs and an upper extremity; or if he were shot through the chest by a bullet no larger than a pencil, it goes clean through him, touches, we will say, nothing of vital importance, and he remains a dangerous man for some time to come.

In savage rushes the lower extremities should be the chief target aimed at; no man can travel with one of the bones of his legs in fragments. In dealing with a civilized foe the shock of a simple flesh wound would probably be enough for most men, and afford them a good excuse for leaving the fighting line, and certainly non-fatal wounds in the chest would cause a gap in the ranks. The question of shock is there infinitely more urgent than the wound.

In considering the nature of the injuries inflicted on bones at distances between 300 and 1,000 yards, it is clear that they have a tendency to resolve themselves into (1) comminuted fractures and pulverizing of the resisting parts of bones, and (2) comparatively clean holes in the nonresisting regions, such as the extremities of the bones; it is evident that a wound near a joint may be much less dangerous than one some distance from it, which is in reality a surgical paradox.

SMALL ARMS IN VARIOUS COUNTRIES.

Reference is given under the name of the country to the Annual of Naval Intelligence containing a description of its service arm. The table opposite gives some details of small-caliber rifles and ammunition.

ARGENTINA.

(Mauser M/91, pages 182, General Information Series No. XII, and 164, No. X.)

Certain improvements have been made in the extractor and bolt head, probably to prevent double feed by having the cartridge gripped as soon as it rises from the magazine.

AUSTRIA.

(Rifle, Mannlicher M/88, page 403, No. VIII. Carbine, Mannlicher M/90, page 117, No. XI.)

After the decision of the small-arms commission some time ago in favor of a caliber of .256-inch, experiments were continued with calibers of .256, .236, .216, and .197-inch. Aluminium cartridge cases were experimented with, but it is believed have proved unsatisfactory. In the Austrian navy the .315-inch Mannlicher carbine is used.

Country.	System.	Date.	Caliber.		Breech system.	Length.		Weight.		Barrel.					Cartridge.							Magazine.			Ammunition supply per man.		Bayonet.		
						Without bayonet.	With bayonet.	Without bayonet.	With bayonet.	Length.	Rifling. Number of grooves.	Rifling. Width.	Rifling. Depth.	Rifling. Twist turn.	Total weight.	Weight of charge.	Weight of bullet.	Total length.	Length of bullet.	Sectional density of bullet (grains per square inch).	Envelope of bullet.	Powder.	Initial velocity.	Kind.	Number of rounds.	Weight of clip.	Number of rounds.	Weight carried.	Type.	Weight.	Length.
			Mm.	*Inch.*		*Feet.*	*Feet.*	*Pounds.*	*Pounds.*	*Inches.*		*Inch.*	*Inch.*	*Inches.*	*Grains.*	*Grains.*	*Grains.*	*Inches.*	*Inches.*				*Ft. secs.*			*Grains.*		*Pounds.*		*Ounces.*	*Inches.*
Argentina	Mauser	1891	7.65	.301	Bolt turns	4.05	5.36	8.9	10		4	.165	.005	9.8	417	40.08	213	3.07	1.21	2,992	Maillechort [1]	Rottweil	2,139	Box	5	92.4	150	9.3	Sword	17.6	15.7
Austria	Mannlicher	1888	8	.315	Bolt straight	4.2	5	9.7	10.6	30	4	.138	.008	9.8	454	42.5	244	2.99	1.25	3,131	Steel, nickeled	Schwab	2,067	do	5	339	150	11.2	Knife	13	9.75
Austria (carbine)	do	1890	8	.315	do	3.28		7.25		19.6	4	.138	.008	9.8	454	42.5	244	2.99	1.25	3,131	do	do	1,902	do	5	339					
Belgium	Mauser	1889	7.65	.301	Bolt turns	4.18	5	8.6	9.6	30.7	4	.165	.005	9.8	441	47	219	3.07	1.20	3,077	Maillechort [1]	L. Wetteren	1,968	do	5	83.2	150	9.7	Knife	15.9	9.75
Chile	Mannlicher	1888	8	.315	Bolt straight	4.2	5	9.7	10.5	30	4	.138	.008	9.8	454	42.5	244	2.99	1.25	3,131	Steel	Black	1,886	do	5	339	150	11.2	do	13	9.75
Denmark	Krag-Jorgensen	1889	8	.315	Bolt turns	4.56	5.22	9.4	9.85		6		.006	11.8	463	31 or 77	238	2.99	1.18	3,053	Maillechort [1] or copper	Smokeless or compressed	1,968	Side box	5		120	8	do	8.5	10.5
England	Lee-Metford	1889	7.7	.303	do	4.15	5.15	9.4	10.3	30.2	7	.197	.004	10	432	38.5	216	3.03	1.22	2,996	Cupro-nickel	Cordite	2,100	Box	Type I, 8; type II, 10.		116	7.1	do	15.5	12
France	Lebel	1886	8	.315	do	4.29	5.49	9.2	10.1		4	.051	.015	9.5	386		208	2.95	1.14	2,669	Maillechort [1]	Vieille	2,073	Tubular	8		120	6.5	Triangular		20.4
France (carbine)	Berthier	1890	8	.315	do	3.1		6.6		17.9	4	.051	.015		383		208	2.95	1.14	2,669	do	do	2,000	Box	3	116					
Germany	Mauser-Mannlicher	1888	7.9	.311	do	4.1	4.75	8.4	9.24		4		.004	9.5	420	42.5	224	3.25	1.26	2,918	Steel, plated with cupro-nickel.	Spandau	2,034	do	5	269	150	10.2	Knife		8.1
Holland	Mannlicher	1893	6.5	.256	do	4.2	5.06	8.65	9.45	31.1	4	.099	.006	7.9	346	36.2	155	3.07	1.24	3,148	Maillechort [1]	Troisdorf	2,395	do	5	154	160	8.6	do	12.8	10.3
Italy	Mann Carcano	1891	6.5	.256	do	4.2	5.21	8.36	9.13		4			7.9	331	32.3	161	3.26	1.20	3,148	do	Balistite	2,296	do	6		192	10.1	do	11.8	11.8
Peru	Mannlicher	1888	8	.315	Bolt straight	4.2	5	9.7	10.5	30	4	.138	.008	9.8	454	42.5	244	2.99	1.25	3,131	Steel	Black	1,886	do	5	339	150	9.7	do	13	9.75
Portugal	Krogatschek	1886	8	.315	Bolt turns	4.3	5.57	10	11.2		8	.157		13.8	542	35.4	246	3.22	1.26	3,156	Copper	Mendonca-Corteso	1,984	Tubular	7		80	6.2	Sword	19.2	16.5
Roumania	Mannlicher	1893	6.5	.256	do	4.02	4.84	8.46	9.26	28.8	4		.004	7.9	345	32.1	162	3.01	1.24	3,148	Steel, nickeled	Smokeless	2,380	Box	5	147	200	10.5	Knife	12	10
Russia	Mosin	1891	7.62	.300	do	4.2	5.68	8.8	9.46	30	4			11.3	393	33	208	2.99	1.20	2,942	Maillechort [1]	Vieille	2,001	do	5	123	150	7.7		14.3	17.4
Spain	Mauser	1893	7	.276	do	4.0		8.7		29	4	.165	.005	9.8	373	37.7	173	3.07	1.19	3,082	Maillechort [1] or copper	Smokeless	2,286	do	5	154			Knife		13.1
Sweden	Remington	1889	8	.315	Block	4.0	5.68	8.8	10.3	33.1	6		.005	11.3	514	53	223	2.99		2,861	Copper	Apyrite	2,004		1		100	7.4			
Switzerland	Schmidt	1889	7.5	.296	Bolt straight	4.25	5.25	9.46	10.3	30.7	3	.157	.004	10.6	424	30	212	3.05	1.13	3,080	Body, paper; point, steel, cupro-nickeled.	Schenker, P. C., 1889	1,968	Box	12	308	100	6	Knife	15.5	11.75
Turkey	Mauser	1890	7.65	.301	Bolt turns	4.07	5.56	8.9	10.2	28.4	4	.165	.005	9.8	417	37.8	213	3.07	1.21	2,9.2	Cupro-nickel	Smokeless	2,139	do	5	92.4	150	9.3	Sword	21.9	18.5

FAVORABLY REPORTED.

Brazil	Mannlicher	1893	7.5	.296	Bolt turns																	Smokeless									
Chile	Mauser	1893	7	.276	do	4.05		8.7		29	4	.165	.005	9.8	373	37.7	173	3.07	1.19	2,892	Maillechort [1] or copper	do	2,289	Box	5	154			Knife		9.8
Mexico	Daudeteau				do																										
Norway	Krag-Jorgensen	1894	6.5	.256	do			8.8	9.35						363	32.3	160			3,109		Smokeless	2,300	Side box	5		150	8.8			
Servia	Koka-Milanovitch	1893	7.2	.284	Bolt straight										359	40	191		1.18	3,015	Nickel	do	2,231	Box	5	92.4					
Sweden	Mauser	1893	6.5	.256	Bolt turns																										

[1] Alloy of copper, zinc, and nickel.

BELGIUM.

(Mauser M/89, page 164, No. X.)

Former defects in this piece (p. 182, No. XII) are said to have been fully overcome, and a carbine of the same model has been issued to the cavalry. New blank cartridges have been adopted. The brass case is prolonged to represent the bullet and the end crimped to a point. The powder charge is contained in a tube within the case and somewhat smaller. On discharge this tube expands to fill the case and the point opens to let out the gas. It is easily extracted and may be recharged many times.

BULGARIA.

(Austrian Mannlicher.)

The arsenal at Sofia has now a plant for the manufacture of cartridges for this piece; capacity, 5,000,000 per year.

CHILE.

(Austrian Mannlicher in use. Favorably reported, .276-inch Mauser.

The latter piece is believed to have been unanimously recommended by the Chilean small-arms commission, and to have the approval of the military authorities.

ENGLAND.

(Lee-Metford M/89, page 405, No. VIII; 128, No. IX; 161, No. X.)

The prejudice against the new rifle when first put in use, especially in India, seems to disappear as the men become accustomed to it; the weight and balance differ from the Martini-Henry, previously used. The necessity for a magazine charger has been shown by injuries caused to the magazine in attempting to crowd in more cartridges than it would hold. Experiments developed the fact that the lands wore away after less than 3,000 discharges with cordite ammunition, while 10,000 black-powder cartridges could be fired without appreciable injury. To prevent this erosion of the barrel, which occurs just in front of the chamber, different methods of loading have been tried, but it is believed thus far with unsatisfactory results. With the piece itself the British war office expresses itself entirely satisfied.

To prevent accidents the dummy bullet has been abolished, empty cases being lengthened to allow of their use in magazine practice. It is announced that all militia and volunteers are to have the Lee-Metford, and that the Martini-Henry rifles in store are to be fitted with the .303-inch barrels. The statement was recently made in Parliament by the

secretary of state for war that there are in India sufficient Lee-Metfords for all European troops and a reserve; in the colonies the infantry is armed with them, and at home there is an ample supply both for regulars and militia, with a reserve. The necessary plant for the manufacture of cordite cartridges is being installed in the cartridge factory at Dum Dum, India.

The British admiralty have decided to begin arming the navy with the magazine gun in the fiscal year 1894–'95. It is intended that once begun the change shall be made rapidly.

FRANCE.

(Rifle, Lebel M/86, page 407, No. VIII; carbine, Berthier M/90, page 121, No. XI.)

Gen. Dodds, in his report on operations in Dahomey, speaks in the highest terms of the fire of the Lebel rifle. Although circumstances did not admit of firing volleys at greater distances than 1,100 yards, the moral effect of the weapon was found to be much greater than that of the Gras, with which the Senegal Rifles were armed, and the accuracy and results of fire from troops which could not be seen and were advancing from an unknown quarter caused great demoralization in the ranks of the enemy.

The changes being made in the rifle are believed to be the following: Fastening more securely the hilt of the bayonet; securing the rear sight mass to the barrel by means of 2 bands; it was formerly brazed; fitting a breech attachment to prevent injury to the firer from gas in case of "spitting," and providing a channel in the bolt head to allow the escape of such gas. As improved, the arm has been tested and favorably reported on, and it is believed is being issued to the infantry.

Experiments have been carried on with pieces of .256-inch and smaller calibers, which for a time gave unsatisfactory results. Favorable results are now reported with the .256 and .236-inch rifles, and rumors are current that it is the intention to adopt one of them.

The navy is being given the Lebel to replace the Kropatschek, caliber 11 millimeters (.433-inch). It has been held that it was first necessary to arm the army reserve, and that for the navy flatness of trajectory is of less importance than for land service. Until further orders the old pieces in the proportion of 1 to 10 of the new ones are to be retained in service for fire with reduced charges.

GERMANY.

(Infantry rifle M/88, page 129, No. IX.)

Reports having been widely circulated that this rifle is obsolete and already abandoned except for the reserves, and that new ones are being made, the German war office has published officially a statement in denial to the effect that new pieces are only made as required to main-

tain the armament, new and improved methods are employed in making, and breech closures are being arranged to prevent injury from "spitting." The swelling and breaking of barrels is due to the presence of foreign substances when firing, especially with blank charges.

For sub-caliber practice some of the M/88 rifles have been fitted with an aluminium bronze tube of 5 millimeters (.197-inch) caliber, having 6 grooves. At 5 meters distance the projectile penetrates 0.197 to 0.236-inch in soft wood; its range is about 88 yards. The targets used are said to be one-tenth the normal size.

It is reported that part of the plan to reduce the load carried by the German soldier is to fix the number of cartridges at 120 instead of 150, as at present.

According to the Militar Wochenblatt, a new cleaning rod has been introduced into the German service, a rod of steel with wooden envelope securely joined to it. The old cleaning rope wore away the metal, especially about the muzzle.

ITALY.

(Mannlicher-Carcano M/91, page 124, No. XI.)

It is believed that this arm is being made entirely in home factories, and that at this time, July, 1894, 170,000 are finished and in use. Last year Italy adopted a carbine, caliber .256-inch, for cavalry, called carbine M/91, similar in breech mechanism to the rifle.

MEXICO.

Although the Daudeteau rifle has been recommended by the smal arms commission for adoption, it would appear that the caliber has not yet been fully decided upon. This system was briefly mentioned on p. 186, No. XII. The rifle, caliber .256-inch, is shown in plate I. The barrel is of steel, specially prepared to resist pressure. The 4 grooves have a left-handed twist of one turn in 7.9 inches and a uniform depth of 0.0043-inch. The barrel is screwed to the breech box, and has lugs for attaching the bayonet and front sight. The rear sight, a hinged bar with sliding leaf, gives, when vertical, ranges from 900 to 2,000 meters (984 to 2,190 yards). The base has steps for ranges from 400 to 800 meters (437 to 875 yards). A spring stop holds the leaf wherever placed.

The breech box, screwed to the barrel, receives the bolt and carries 2 spring clips, 1 on each side, which hold the cartridges down against the lifting pressure of the magazine feed springs. These clips prevent double feed, as explained hereafter.

The safety attachment *a*, see figure, when thrown into use, serves to hold the cocking piece, and consequently the firing pin in the position of

"ready," and in this position prevents firing or opening the breech. A notch *r* for the safety catch is cut round the left side of the cocking piece, the catch itself being fixed to the left side of the breech box. The thumb piece being turned to the right, the catch entering the groove fixes the cocking piece (secured to the head of the firing pin), and does not allow the piece to be fired or the breech to be opened.

The bolt stop *b* is also shown.

The breech closure is of two models, both worked by a bolt handle turning down to the right; in one, see figure, the bolt cylinder is a single piece, carrying at its forward end the two symmetrical locking lugs. A screw plug, through which the firing pin passes, closes the rear end of the bolt, holding in its place the spiral spring. The cocking piece is screwed to the rear end of the firing pin. The extractor *p* is dovetailed to the bolt, having a stop to prevent it drawing out.

In the second model, the cocking piece *n* is held to the firing pin by a T clutch, and there is a movable head bearing the locking lugs. The firing pin is put into the cylinder from its forward end, the bolt head then put on and held by a connecting screw; it partakes of all motion of translation and rotation of the bolt.

The trigger guard and magazine are in one, and carry the ejector and trigger mechanism. The right side plate of the magazine is removable. It holds 5 cartridges, and a sixth may be placed in the chamber by holding down the upper one in the magazine while the bolt passes over it in closing.

The elevator has two arms and two springs.

The ejector is shown in the figure. The spring piston allows the ejector to be pushed down as the bolt passes over it, rising as the bolt is drawn to the rear to eject the shell.

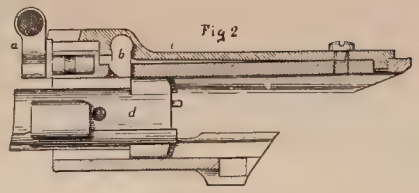
The stock is a single piece of walnut; a wooden hand guard is used.

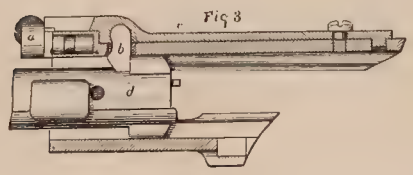
The clips or chargers are of two kinds, one of which admits of use either side down.

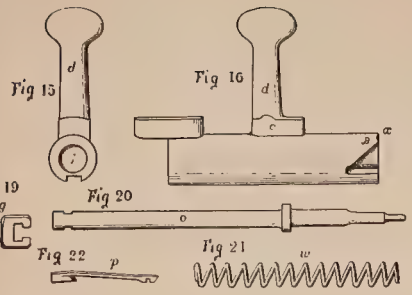
The arrangement for preventing double feed is as follows: The spring clip on the left of the breech box holds down the upper cartridge, but at such a height that the bolt in closing carries it into the chamber. During this movement the next cartridge is held down in its place by the spring clip on the right of the breech box until the bolt handle is fully turned down, when the shank of the latter takes against a stud of the right spring clip and releases the second cartridge (now the upper one in the magazine), and allows it to rise ready for the next forward movement of the bolt. Jamming the empty case with the next cartridge is precluded, as the upper cartridge can not be seized by the bolt head until the empty case is ejected.

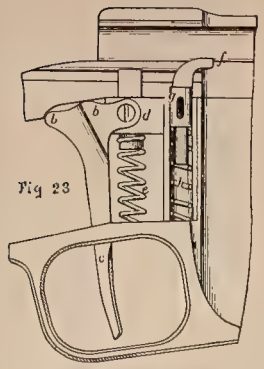
This piece is further shown ready for firing, and again with a shell about to be thrown out.

a, safety attachment.
b, bolt stop.

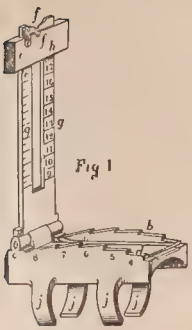




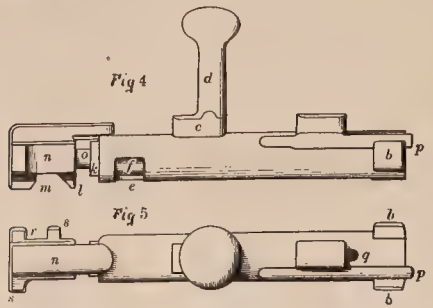


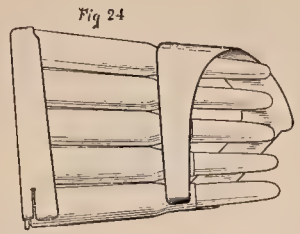


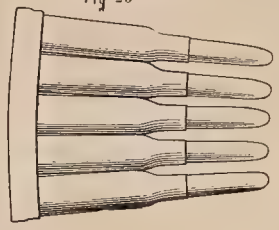
f, spring, piston ejector.

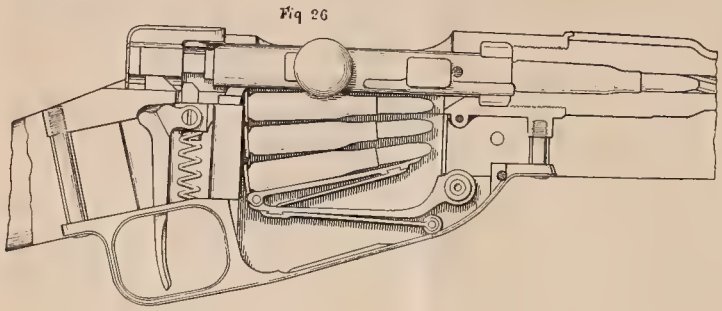


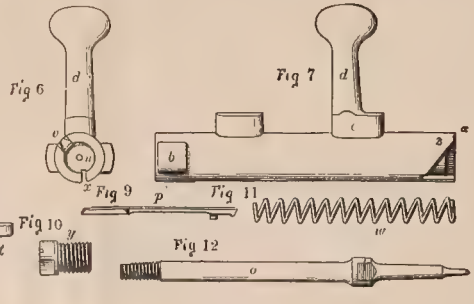
Bolt cylinder, a single piece.

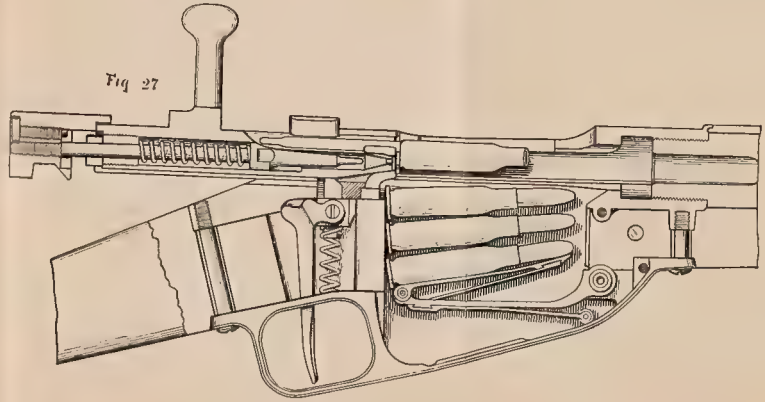


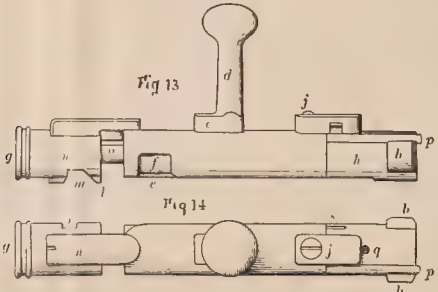












Bolt cylinder in two parts, shown in figs. 16 and 17.

NORWAY.

(Krag Jorgensen M/93. System described page 165, No. X.)

Various authorities state that the Krag-Jorgensen, caliber 6.5-millimeter (.256-inch), has been adopted to replace the Jahrmann now in use, some of the new arms to have been purchased in 1893. A press report says:

The first tests go back to 1891. After having determined by firing the kind of powder to use, the trial commission commenced in the autumn of the same year to seek for the best caliber. Arms of calibers 8, 7.5, and 6.5 millimeters (.315, .296, and .256-inch) were presented, and the latter showed itself superior to the others from a ballistic point of view; besides greater accuracy it had a sensibly flatter trajectory. With the trial cartridge the initial velocity and pressure observed with this arm were 2,300 foot seconds and 58,800 pounds per square inch. The pressure increasing as the caliber decreased, and that already shown being very great, double that in the Jahrmann, 10.15-millimeter (.40-inch), it was decided not to search for a caliber below .256-inch. Nevertheless the commission tested a 5-millimeter (.197-inch rifle, and thus assured themselves that the pressure increased very greatly without appreciable advantages.

Finally, to determine whether the .256-inch piece could stand the pressure to which it would be subjected, without having to fear, in continued firing, an enlargement of the chamber or wearing of the lands sufficient to affect its accuracy, one piece was fired 4,000 times with the normal charge and continued to perform satisfactorily. The commission were then satisfied as to the strength of the barrel.

Having definitely adopted the .256-inch, with the idea of better judging of the value of such an arm, it was tried in competition with the .315-inch, in general use, as to penetration, drift, the influence of the wind, determination of sights, probable deviation, etc. These trials showed that with the smaller caliber a much flatter trajectory was obtained, a much greater accuracy, especially at the shorter distances; that the drift and influence of the wind were sensibly the same with the two calibers; and, finally, that the smaller bullet penetrated further in wood and as far in earth as the larger. It also was less deformed.

In all these firings bullets of lead with envelopes of nickel-plated steel or of nickel were used. It was remarked that their penetration in wood attained its maximum at 330 feet, being 32 inches for the .315-inch and 36 inches for the .256-inch; it then decreased gradually for each 100 meters (109 yards). In light sand, on the contrary, the penetration was relatively small, 7.2 inches for the larger, and 11.2 for the smaller bullet, then increased for each 100 meters (109 yards) up to 400 or 500 meters (437 or 547 yards), when it was 16.8 and 18 inches, respectively, for the two calibers. Beyond the latter range the penetration was practically the same for both calibers. This anomaly apparently shows that the bullet meeting, at short range, with great velocity, a substance with the resistance of light sand is instantly deformed, which interferes with its penetration; while when the velocity has at greater distances sensibly decreased such deformation does not take place.

Having fixed on the caliber and general dimensions of the piece the commission passed to a study of the breech closure and magazine. The most recent types, the Krag-Jorgensen (Danish), Austrian Mannlicher, Portuguese Kropotschek, German Mauser of Spandau, Belgian Nagant, English Lee-Speed, SwissSch midt, Marga, etc. were submitted to comparative tests, after which the commission decided to place in further competition only the Krag-Jorgensen, the Mannlicher, and the Mauser. These three models were subjected to tests of every kind. The question of safety of mechanism, rapidity of aimed fire both as a single-loader and magazine arm, with

magazine full and empty; rapidity of unaimed fire, the dust and rust tests, resistance to excessive charges giving pressures as high as 73,500 pounds per square inch, and also defective-cartridge tests, were successively the object of study, after which the preference was given to the Krag-Jorgensen for the following reasons:

This arm is excellent as a single-fire or magazine arm, and is always ready for use even if the magazine system sustains injury. The magazine can be filled and refilled, the piece being loaded and ready to fire. In passing from magazine fire to single fire the magazine remains intact, and one has always ready 5 cartridges therein, while in the Mauser, this number is reduced to 4. As for the Mannlicher, it can not be used under the same conditions.

Finally, a great advantage of the Krag-Jorgensen, the filling of the magazine is done without effort whatever the position of the man firing, while with the Mannlicher and Mauser the man has to use a certain force and expose himself slightly if lying down. The mechanism of the Krag-Jorgensen works always with the greatest certainty; it is easily cleaned, and its manipulation does not require previous exercise, neither is it necessary to have a charger to fill the magazine.

The rifle is provided with a short bayonet with steel scabbard. The sight is graduated for each 50 meters up to 1,000 and for each 100 meters up to 2,200. The weight of the arm without bayonet is 8.8 pounds, with bayonet, 9.3 pounds; weight of cartridge 363 grains. The men will carry 150 cartridges.

Later reports say that a joint commission composed of 3 Swedish and 3 Norwegian officers, instituted at Christiania late in 1893 to select rifles of the same caliber for each country, have decided on the Krag-Jorgensen for Norway and the Mauser for Sweden, both of .256 caliber, and to use the same ammunition. The commission have recently been occupied with the question of a packet to answer for both pieces.

ROUMANIA.

(Mannlicher M/93.)

The M/92 Mannlicher adopted by Roumania has been modified on the recommendation of Roumanian officers, the principal changes being the addition of a ramrod and the substitution of a jointed lifting lever for the single lever of the magazine. As modified it is called M/93. The M/92 is to be given to the gendarmes. This arm, M/92, is illustrated in Pl. II, figs. 1–18, and described as follows (both illustration and description being taken from the Journal of the Royal United Service Institution, March, 1893):

The 6.5-millimeter (.2559-inch) Mannlicher system magazine rifle (figs. 1–7) reproduces the chief features of the German rifle, pattern 1888.

The most important differences consist in the reduction in caliber, in the omission of the barrel casing, in some modifications in the bolt and magazine mechanism, in the sighting, and in the furniture. These differences will be noted in briefly recapitulating certain details of construction which are already familiar.

Barrel.—The barrel is covered by a wooden hand guard, cut out for the sight and secured by two curved springs, which extends from the body to the middle band. This arrangement allows the rifle to be laid hold of by the barrel, however hot the latter may be. The four grooves have a twist of one turn in 20 centimeters (7.874 inches), or about 31 calibers. The sight slide has a spring catch with tooth, which engages in suitable notches cut in the left side of the leaf. When the rifle is at the shoulder, the slide can be raised by the thumb of the left hand and fixed at any elevation. The bayonet is attached to the upper band.

Fig. 4. Sword-Bayonet ($\frac{1}{4}$)

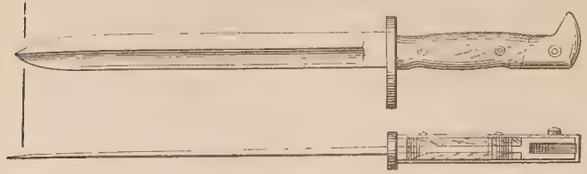


Fig. 1. Complete Rifle ($\frac{1}{4}$) Elevation.

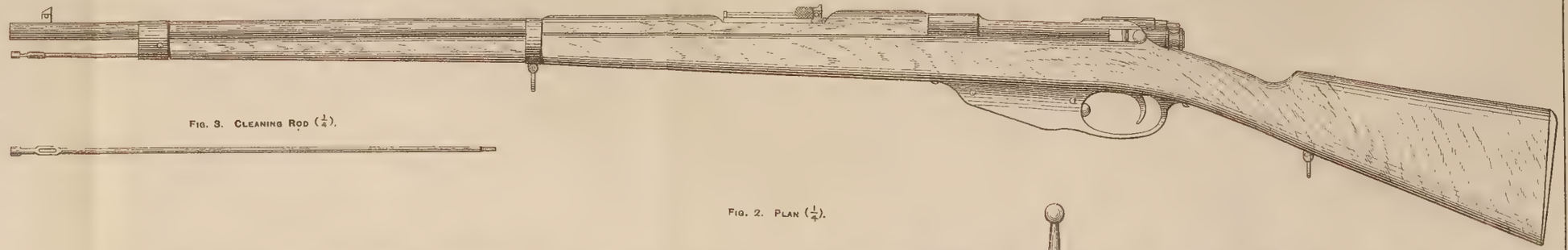


Fig. 3. Cleaning Rod ($\frac{1}{4}$).

Fig. 5. Scabbard ($\frac{1}{4}$).

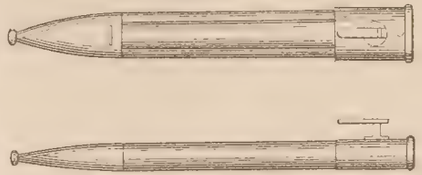


Fig. 2. Plan ($\frac{1}{4}$).

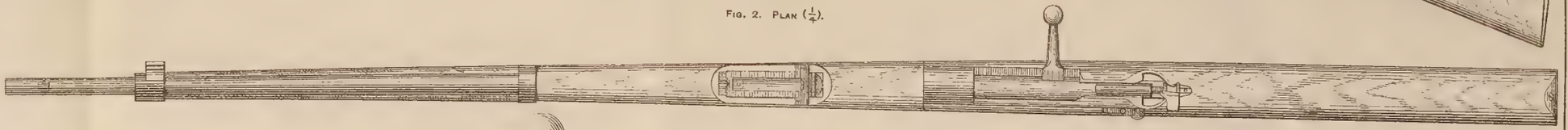


Fig. 6. Longitudinal Section, Breach open ($\frac{1}{2}$)

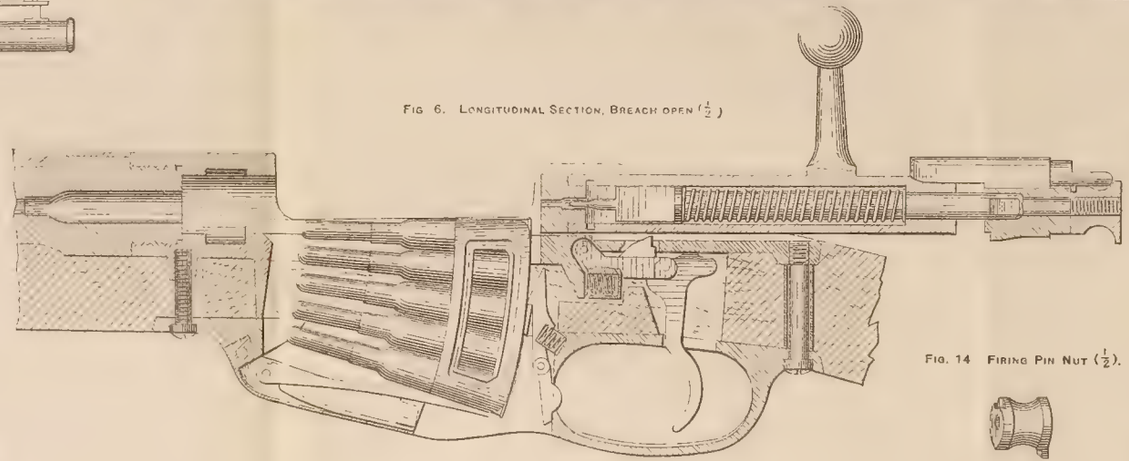


Fig. 7. Longitudinal Section after firing of First Cartridge ($\frac{1}{2}$).

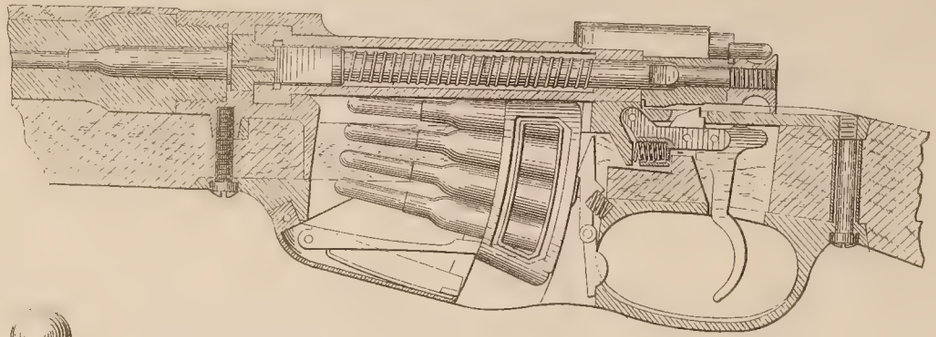
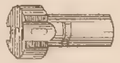


Fig. 9 Ejector ($\frac{1}{2}$)

Fig. 10. Extractor ($\frac{1}{2}$).

Fig. 11. Bolt-Head ($\frac{1}{2}$).

Left Side.



Right Side

Fig. 14 Firing Pin Nut ($\frac{1}{2}$).

Fig. 8. Bolt Cylinder ($\frac{1}{2}$).

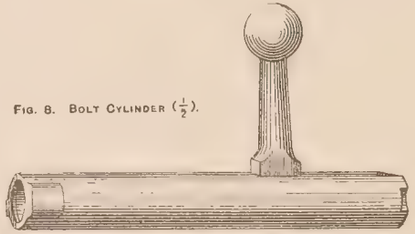


Fig. 12. Mainspring ($\frac{1}{2}$)

Fig. 13. Firing Pin ($\frac{1}{2}$)

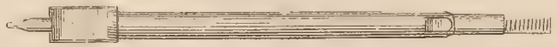


Fig. 15. Bolt ($\frac{1}{2}$)

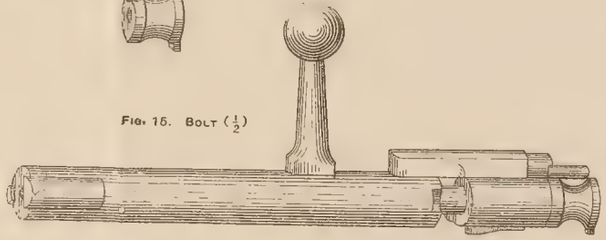


Fig. 16. Safety Bolt ($\frac{1}{2}$).

Fig. 17. Safety Bolt Spring ($\frac{1}{2}$).

Fig. 18. Cocking Piece ($\frac{1}{2}$).

Bolt mechanism (*figs. 6–18*).—The bolt cylinder has two locking lugs in front, opposite to one another, and horizontal when the breech is open; the right lug is cam-shaped, and serves to start the extraction of the cartridge. The movable bolt-head, which does not rotate with the bolt, has a flat face; on the left it carries the ejector, on the right the extractor, which both project beyond its face. The ejector has a projection of dove-tail form, which can travel backwards and forwards in a longitudial groove in the bolt-head. It acts as follows: When the bolt cylinder is turned down to the right, the ejector rests in its recess in the front of the body, and keeps the bolt-head in its place. When the lever is raised into the vertical position, the left locking lug is in position to actuate the ejector. Finally, in the last portion of the travel to the rear of the bolt, the ejector is caught by a spring tappet fixed in the body, which pushes the ejector to the front, the latter throwing out the empty cartridge case. The cartridge, on leaving the magazine, is immediately caught by the hook of the extractor, and thus accompanies the bolt mechanism in all its backward and forward movements. This arrangement is to prevent "double loading," that is to say, the ascent of the top cartridge in the magazine before the preceding cartridge has been extracted.

Magazine mechanism (*figs. 6 and 7*).—The magazine forms one component with the trigger guard, and contains the feeding lever actuated by a flat spring, and the catch for the clip, with spiral spring. It receives a steel clip containing five cartridges. When the last cartridge has left the clip, the latter falls by its own weight out of the opening in the bottom of the magazine; if it does not do so, the introduction of the next clip suffices to throw it out. To remove a clip still containing cartridges, all that is necessary is to open the bolt and press the button of the catch with the finger.

There have been rumors that the high pressures (58,800 pounds per square inch) cause injury to the piece when a few thousand shots have been fired, viz, jogging of the breech bolt, breaking of the extractor, deterioration of the barrel, etc., and that to reduce this pressure the powder room in the shell is to be increased, involving alterations in the piece to take it. Confirmation of this rumor has not reached this office. The entire order, 111,000, was to have been filled by May 1, 1894.

The new carbine, same system, uses the same ammunition as the rifle, but has shorter barrel and stock and a different arrangement of bands, sling span, and hand guard.

RUSSIA.

(Mouzin M/91.)

The work of re-arming has been progressing during the past year, the arms being made in large numbers in France, and it is reported that an order has been placed in Belgium. The following are the most important changes recently made in the piece: The omission of the metallic plate in rear of the trigger-guard, which carried a cleat or support for the right hand in gripping the small of the stock; the addition of a wooden hand-guard, and the modification of the ramrod and cleaning gear.

Rifles of .256-inch caliber, among them the Daudeteau, have been experimented with.

SERVIA.

(Mauser-Milanovitch. M/80, caliber .40 inch.)

There are rumors of the intended adoption of a magazine arm of 7.2-millimeter (.284-inch) caliber, system Koka-Milanovitch, a straight pull piece with box magazine, loaded by a clip holding 5 cartridges, as in the Belgian Mauser. In its trial ammunition was used, the details of which are given in the table.

SPAIN.

(Mauser M/93.)

This piece differs materially from the Belgian Mauser. Plate III gives a good idea of the breech bolt and magazine as modified, and also shows the safety attachment. The improvements and the advantages claimed for them are as follows:

The extractor, see figure, is considerably stronger in all its parts than heretofore; it is on the right of the bolt, to which it is joined by pushing it onto a ring, the latter being sprung over the bolt. The extractor is fixed there by the catching of the rib, lying closely behind the body of the extractor, into a corresponding groove in the bolt. Thus the extractor is far more durable; it can be taken off and put on by hand, whereas in the former designs a special tool was necessary, which sometimes broke itself or broke the extractor hook. The cartridge is ejected to the right of the breech and can do no injury. As soon as the cartridge rises from the magazine its flange is seized by the extractor hook and thereafter it follows any forward or backward movement of the bolt, preventing double feed.

The cocking piece *g* has lugs *h* on the right and left, which in moving the bolt forward slide in the receiver grooves for the locking lugs. This serves to hold the cocking piece more securely and closes the grooves in the receiver against the escape of gas to the rear in case of defective shells.

The trigger mechanism is quite different from that of Mauser's former models, the object of the change being to prevent firing when the bolt handle is not completely turned down. Reference to fig. —— will show the working of this safety arrangement. The trigger is pivoted at *c* (moveable pivot) to the trigger holder, and both are pivoted at *b* (fixed pivot) to the receiver. The trigger holder has 2 lugs, *a* and *f*. The latter, engaging the cocking lug *i*, holds the cocking piece or dog when the piece is cocked, as is usual in bolt guns; the lug *a* rises through the receiver into a hole *k* in the bolt as the trigger is pulled. This can not be done until the bolt handle is completely turned down, as then only is the hole in the bolt directly over that in the receiver, through which the lug rises.

Fig. 1.

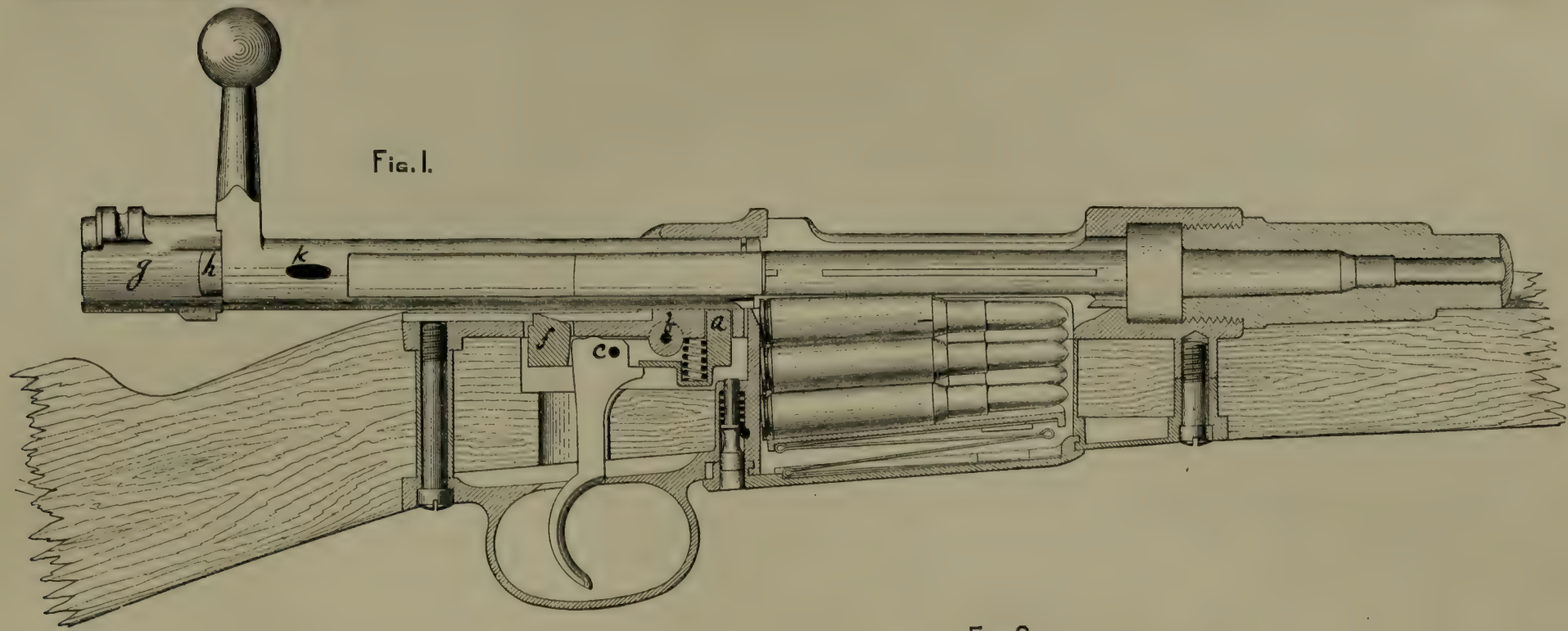


Fig. 2.

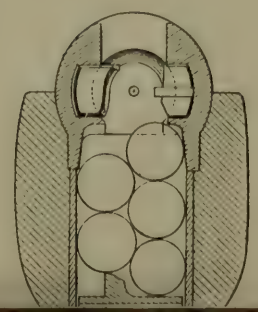


Fig. 3.

The bolt stop has been altered; it is screwed to the receiver and not fixed by a pin as formerly. It can thus be taken off more easily.

The magazine is made in one with the trigger guard, which is fastened to the rifle by the tang screw and front trigger guard screw. The feed plate and springs are not fastened to the magazine proper, but to its bottom plate, easily detachable with the aid of a common cartridge.

The wooden hand guard reaches from the rear sight to the lower band, and is fixed by catching in front beneath the lower band and behind by means of a sheet-metal cap below the sight base; thus the hand guard is more securely fixed and the hand better protected against heat.

The clip has wider sides, making a more rigid packet, and it is better guided in charging.

The firing pin and its nut are no longer joined together by a screw thread, but by a bayonet clutch, consequently mounting and dismounting are much more simple and certain. The disadvantage of the old system with 24 threads was that it was possible in joining them to leave one or more threads unturned. This resulted in lengthening the firing pin and perforating the primer.

This piece is officially designated the Spanish Mauser, M/93. Four hundred thousand have been ordered. It is the present intention of the Spanish authorities to make 200,000 in Spain, the remainder to be made at the company's works in Berlin.

SWEDEN.

(Remington transformed, M/67–89, page 168, No. X.)

The joint commission of Swedish and Norwegian officers appointed to select rifles of the same caliber for the two countries are reported to have recommended the Mauser for Sweden and the Krag-Jörgensen for Norway, both of caliber .256-inch. Sweden has purchased a number of the Mausers for further trial. It is not yet known whether this arm will be manufactured in Sweden or at the company's works in Berlin.

SWITZERLAND.

(Schmidt, M/89, page 168, No. X.)

It is stated on good authority that the Swiss contemplate no change, having but recently finished re-arming with the present piece. Its disadvantages are given by experts as follows:

The magazine projects too far and interferes with carrying the piece on the shoulder. In removing the magazine difficulty is sometimes experienced with the lever bolt holding it in place. The chargers must be placed over the receiver in a certain way.

The breech-closing mechanism is complicated and its construction unsatisfactory; it is difficult to clean. If the piece is lowered smartly or the butt strikes the ground the breech opens of itself. When, having fired, the breech is opened, keeping the piece at the shoulder, the firer may be struck in the face by the empty shell, unless he carries his head to one side. The two parts of the firing pin are not properly joined, causing missfires. The sight is inconvenient to handle, especially at short distances. Finally, the number of separate parts (67) is too great.

Trials have been carried on of a modified Schmidt rifle having the locking lugs placed nearer the fore end of the bolt, and the latter shortened nearly an inch.

A carbine has been adopted for cavalry using the same ammunition as the rifle. Weight, about 6.6 pounds; length, about 4 feet 1 inch, and precision good to about 1,000 yards.

TURKEY.

(Mauser M/90.)

Reports from Constantinople are to the effect that the Mauser rifle factory is to supply 154,000 of these arms before February, 1895. This would insure uniformity in the armament of Turkish infantry.

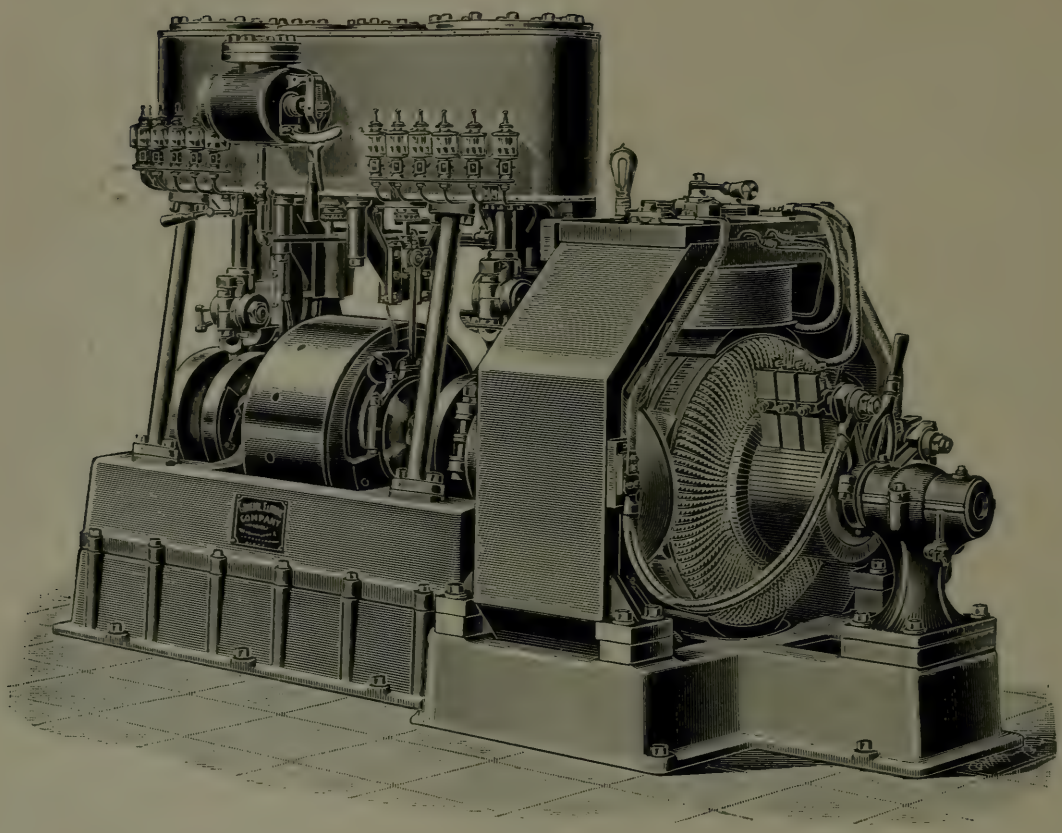


Fig. 1.

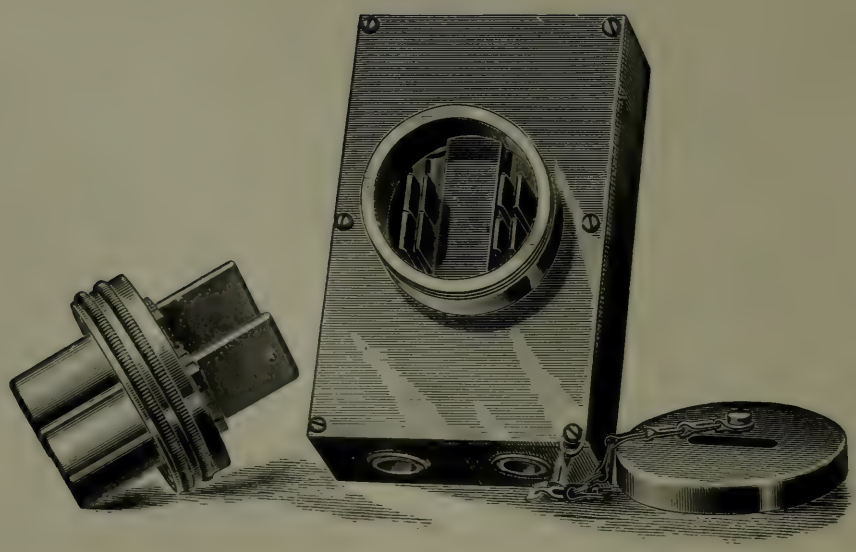


Fig. 2.

V.

NOTES ON NAVAL DYNAMO MACHINERY.

By Lieut. J. B. Murdock, U. S. Navy.

[Republished from the proceedings of the U. S. Naval Institute.]

* * * * * * *

The Bureau of Equipment now issues standard specifications for nearly all of the electrical material used aboard ship.

The specifications for generating sets were referred to in General Information, Series No. XI, and an illustration given of an eight-kilowatt set, of the new type, as constructed by the General Electric Company. The principal points of the specifications which determined the construction of this type were the continuous operation of the engines without oil in the steam spaces, the provision limiting the heating of the dynamo, and the absence of external magnetic field. Two 8-kilowatt sets of this type have been placed aboard the *Concord* and two others aboard the *Bennington*. Sixteen-kilowatt sets are in use on the *Dolphin*, *Detroit* and *New York*, while 32-kilowatt sets, shown in fig. 1, are also installed aboard the latter vessel. Similar sets of various sizes are constructed and in process of installation aboard the *Maine*, *Cincinnati*, *Raleigh*, *Montgomery*, *Marblehead*, *Columbia*, *Puritan*, *Terror* and *Amphitrite*. Under these circumstances a few details may be of interest.

The finished weights and dimensions are as follows:

Amperes.	Weight.	Length.	Width.	Height.	Watts per pound.
	Pounds.	*Ft. In.*	*Ft. In.*	*Ft. In.*	
400	11,100	9 2	4 1	5 9¾	2.89
300	9,100	8 ¾	3 10⅛	5 5½	2.61
200	6,160	6 9½	3 4½	5 ¼	2.60
100	3,750	5 6¼	2 10	4 9	2.13

The construction of the engines is much heavier than was formerly the case, the number of breakages of those in use in the service having apparently shown that strength had been unduly sacrificed to decrease weight. The new engines have more clearance in the cylinders, and

although this is uneconomical so far as steam is concerned, it is of value when working with wet steam or when threatened by water. As the presence of water in the cylinder has always been a cause of damage to dynamo plants, special attention is given to drainage, and the cylinders are fitted with both hand and automatic relief valves. The governor is of the common automatic type, the weights being placed in a wheel midway between the cranks. The space allowed is barely sufficient in the smaller engines, and they do not govern as closely as the larger sizes. The closest regulation has been obtained from the 24-kilowatt sets which, on test for acceptance, averaged only five revolutions change of speed from full load to no load, the momentary increase, when all load was thrown off suddenly, being only eight revolutions. The requirement of the specifications, that the variation of speed should not exceed eight revolutions when the steam pressure changed from 60 to 100 pounds, necessitates considerable reserve power at ordinary working pressures, and even more was furnished, the engines having carried full load on the dynamos at 35 pounds pressure, although intended for 80, and at the latter pressure having under test carried double load. The pistons are without packing rings, and all four sizes of the engines have the same stroke, 6 inches, the cylinder diameters being respectively 13, 10¾, 8½, and 6½ inches. All bearings are of gun-metal, except in the 32-kilowatt sets, where the crank-pin boxes are partially babbitted. The cranks are set at 90 degrees, causing a poor balance and consequent noisy working, probably the most serious defect of the engine.

The dynamos are four-pole, compound wound. The frame and field cores are of cast steel in one piece, the pole pieces being bolted on. The field coils are cylindrical and wound on vulcabeston spools, the spools on the small dynamos being coned, on account of the lack of room. The series coils are next the core, the ends being brought out directly opposite each other, and all four spools are coupled in series. The shunt winding is outside the series, and the spools are also in series. This arrangement greatly facilitates repairs, as a defective spool can be removed and rewound without touching the others.

The shape of the field frame and the position of the coils are such as to minimize all external magnetic field. No magnetism can be detected on the outer part of the frames except in one or two positions, and the external field is imperceptible on a horizontal force instrument at a distance of 15 feet. While it may be urged that the influence of a dynamo placed in an iron compartment is imperceptible on a compass at a distance, there are instances on record in which peculiar arrangements of steel bulkheads have resulted in a deflection of the compass whenever the dynamos were in operation. This magnetic effect could be easily counteracted, but the present policy of entirely preventing it is a most effective safeguard. The multipolar type of dynamo allows of reduction of weight, although necessitating somewhat greater floor space.

The armatures of the new type dynamos are Gramme wound, and slide off and on a shaft common to both engine and dynamo, being secured by a feather and slot and kept in place by set-screws. The armature is built up of soft iron disks, clamped together, there being no through bolts. In the first armature constructed for the 16-kilowatt (200-ampere) dynamos it was found on making efficiency tests that the total core loss due to eddy and foucault currents in the mass of the armature itself was 1,207 watts, and the armature, when run on open circuit, the field being separately excited, heated to 22° F. above the air in 2¾ hours. As the limit of heating in a full load run of four hours is 50°, this allowed but little margin for the heating due to the current, and armatures tested under these conditions heated from 60° to 80° above the air. A new type of construction was therefore adopted. The core disks were held together by clamps, all through bolts being removed and the disks themselves being carefully insulated. The armature winding was also changed, being made of stranded conductors, each wire being separately insulated before stranding. The effect of these changes was most marked, the total core losses falling below 700 watts, and heating on the full load run of four hours to about 45° F.

The commutator is of bronze, the number of segments varying from 120 to 144 in the different sizes. The commutator has cross connections inside for use with two sets of brushes.

As a result of the range of steam pressure called for under the engine specifications, and of the low heating limit allowed for the dynamo, the generating set possesses great reserve power. In one of the tests, while operating two 200-ampere dynamos in multiple with about 80 pounds of steam, the whole load of 400 amperes was inadvertently thrown on one dynamo. No noticeable diminution of speed of the engine occurred, nor was there any sparking on the dynamo, and the overloading was manifest only on the ammeter. When the double load of 400 amperes was thrown off it was not necessary to adjust the brushes, the sparking being insignificant. This capacity for carrying an overload is of the greatest value in ship work, as, in case of damage to one set, all the work could be done by another. There is no question of the capacity of the dynamo to carry 150 per cent of its rated load for long runs without material damage, nor is there any lack of power in the engine. In any particular case the amount of safe overloading would probably depend upon the heating of engine bearings and crank pins.

All dynamos as yet used in our service have been fitted with rheostats in the shunt field, to admit of variation of the voltage. This design has found but little favor in other countries, either for commercial or marine work, but it is universally adopted in the United States, and the ease of adjustment thus obtained is so great that no other system is considered. Commercial practice also includes an adjustable resistance in parallel to the series field, and this is authorized on board ship when the dynamos are required to operate in parallel.

WIRING.

The greatest care has always been taken in wiring vessels of the U. S. Navy, and the standards of insulation and of work are of the very highest order. The student of electrical engineering can nowhere find a better example of a thoroughly high grade installation than on one of our ships. This excellence of work is, under the prevailing high wages and short working hours, obtainable only at a great expense as considered with the cost of foreign installations, but economy should not be sought in any changes involving the efficiency of the installation or the lowering of the standard of work.

The general system of wiring is to run two sets of circuits. One set, called the "battle circuits" includes all lamps necessary in action. These circuits generally include all lights in fire and engine-rooms, coal bunkers and store-rooms below the protective decks, lights not needed in action being turned off separately. On upper decks the battle lanterns are so placed as not to show from outboard. All exposed lights and all used for ordinary illumination are put on "the lighting circuits." On going to quarters all these lights are cut out at the switchboard in the dynamo-room, and there is no necessity for an inspection of the whole ship to determine if unauthorized lights are in operation.

To further insure proper lighting in action the ends of the battle mains are interlocked at many places in the ship, and the circuits are kept as much as possible below the protective deck. This system becomes more important as the necessity for electrical energy in time of action increases, as it is doing daily by the extended use of electric motors.

The number of circuits at the switchboard has been decreased of late by the use of "feeders." These are heavy conductors leading from the dynamo-room to the general location to be lighted, where, by means of a "feeder junction box," they branch right and left into "mains." Each pair of mains may have a feeder box placed in it, allowing its division into two other pairs of mains. These feeder boxes contain no fuses, and the mains leading from them must therefore have a safe carrying capacity equal to that of the feeder fuses at the main switchboard. Switches may be interposed in the mains as desired, and in case the arrangement of the ship is such as to necessitate the use of many switches on the lighting circuits it would be advisable to place the feeder boxes and switches together in sub-stations.

Subdivisions, known as "branch mains," are taken off the mains by means of ordinary junction boxes, each of which contains a fuse. Branches may be taken from the branch mains in the same way. Ordinarily it is not intended that more than four lights shall be taken off one junction box, and the specifications call for an unbroken wire from the box to the lamp. All wires are inclosed in pine moldings, there being at least three-fourths of an inch of wood between wires, and three-

eighths between either wire and any metal connected with the ship. As a rule all fixtures are secured on wood, avoiding a heavy ground in case of low insulation resistance on the sockets or other metal parts. Of late, commercial ceiling fixtures, ceiling cut-outs, and non-water tight junction boxes have been installed in quarters where their use in nowise impairs the insulation efficiency of the plant, with the idea of avoiding the expense and loss of light attendant on the use of standard water-tight fixtures. There is probably no case recorded of any report having been made complaining of too much light in any of the living spaces of a ship. The tendency is always to seek a brilliant illumination, and it is very poor economy to obtain light and then interpose heavy ground shades for the purpose of subduing it.

The search-light leads extend from the switchboard directly to the projectors or to the control stands, being broken at intervals of about every 50 feet for convenience in installation, the ends being joined in search-light junction boxes, which contain no side holes and no fuses, being used simply to avoid splices.

The standard wire is now without any lead covering. The latter was used as a waterproof covering to the insulation and as protection from mechanical injury. In neither of these two respects did it prove satisfactory. The spar-deck and engine-room circuits of several ships, wired with lead-covered wire, have had to be entirely renewed at the end of three years. On removing the old wire it is found that the handling involved in getting it into place is very liable to break or dent the lead, admitting water to the insulation and retaining it. Any defect in the insulation will then cause a bad ground. The lead covering practically puts all grounds in parallel, and is, moreover, objectionable from its extra cost and weight. The new standard wire depends for its durability on the insulation being to a greater extent of vulcanized rubber, and on a heavy braid covering which is saturated with a waterproof compound. Sufficient mechanical protection is given by the molding. The new wire is, of course, to a certain extent experimental, and if experience should show that it is inferior to wire of the same grade covered with lead the latter might be again used.

In order to obtain the high insulation resistance called for in naval plants great care is necessary in installation. The standard called for, of at least one megohm on each circuit, and 500,000 ohms on all in parallel, is intended to secure care in installation, and would be unobtainable in anything but dry weather, the surface conduction over socket shells and over exposed metal parts of the circuit being sufficient in ordinary weather to bring the insulation far below that figure. The general precautions taken, in order to reach the limit, are the use of high insulation wire and the separation of all parts of the circuit from the metal of the ship by means of wood molding, or by hard rubber tubing when passing through bulkheads and beams. Grounds frequently occur on the lamp sockets, which would be dead grounds if it were not for the interposition of wood,

The high insulation called for is not only a guarantee of good material and careful work, but also insures against accident.

With telephones, fire and water alarms, torpedo and gun circuits, helm and revolution indicators, and various kinds of call signals, all operated by electricity, high insulation of the dynamo circuits becomes a necessity, a cross between two wires involving many possibilities of trouble. An electric-light system would probably operate perfectly well on an insulation of 500 ohms, although there would be a greater risk of sudden break down aboard ship than would exist in shore plants. The specifications call for the best possible work in installation, as a guarantee of good operation and durability. Every care should be taken to localize and eliminate even light grounds. Nearly all the trouble is experienced on the fire-room and spar-deck circuits, and arises very largely from the water-tight fittings not being properly closed and screwed up, allowing damp air or water to get inside.

In laying out the wiring the size of the wires is determined under three provisions of the specifications. One stipulates that no single conductor shall be smaller than No. 16 B. W. G. The second calls for a cross section of 1,000 circular mils (1 square inch equals 1,273,236 circular mils) for each ampere of current at full load, authorizing a double current in search-light leads. The third calls for such a cross section that the fall in potential between the dynamo and the farthest lamp shall not be more than 3 per cent on full load.

In laying out a ship installation the calculations are made on the area of the conductors in circular mils. As stranded cables are used for all sizes above No. 14 B. W. G., results can not be expressed in terms of diameter. The exact area required can not always be obtained in stranded cables, and the nearest size admitting of convenient manufacture is therefore taken. The following are the sizes of conductors commonly used in the service:

	Circular mils.		Circular mils.
No. 16 B. W. G	4,225	7-16 B. W. G	29,575
No. 14 B. W. G	6,889	7-15 B. W. G	36,288
20-30 B. W. G. flexible cord	2,880	19-18 B. W. G	45,619
7-22 B. & S. flexible cord	4,498	19-17 B. W. G	63,916
7-20 B. W. G	8,575	19-16 B. W. G	80,275
7-18 B. & S	11,368	37-18 B. W. G	88,837
7-19 B. W. G	12,348	37-17 B. W. G	124,468
7-16 B. & S	18,080	37-16 B. W. G	156,325
7-17 B. W. G	23,548		

The ruling condition of manufacture of stranded cables is that the cable must consist of 7, 19, 37, or 51 wires, if all are of equal size. By varying the size of each of the component wires stranded cables of any desired cross section may be made.

The determination of the cross section of the mains is as follows: The maximum drop allowed is 3 per cent on 80 volts, or $2\frac{4}{10}$ volts;

$$\therefore 2.4 = \text{current} \times \text{resistance of mains.}$$

The resistance of a conductor of pure copper is commonly expressed by

$$R=\frac{\text{Length of conductors}\times 9.612\,(1+at)}{\text{Area of conductor in circular mils}},$$

9.612 being the resistance in legal ohms at 0° C. of a wire 1 foot long and 1 circular mil in area. Adopting 70° F. as an average temperature for wires on shipboard, this expression reduces to

$$R=\frac{\text{Length}\times 10.42}{\text{Area}},$$

Although navy specifications call for pure copper wire, the twisting involved in making stranded conductors shortens the cable from three to five per cent and practically diminishes its conductivity to that extent. Introducing an allowance of four per cent, we have

$$R=\frac{\text{Length}\times 10.83}{\text{Area}}$$

Substituting in the first formula and reducing we have

$$\text{Area in circular mils}=4.5\times LC,$$

L being the total length of wire in circuit in feet (both conductors) and C the current in amperes.

Making C unity and substituting 1,000 circular mils, the corresponding area called for by the navy specifications, we obtain a value of L of 222 feet. For shorter lengths than this, the area calculated from drop alone would be less than allowed by the specifications for carrying capacity. We have, therefore, the simple rule: For mains extending to shorter distances than 111 feet from the dynamo, the area is determined by allowing 1,000 circular mils per ampere; for greater distances, the area must be determined from the fall of potential alone by the above formula.

A useful modification of the formula is to determine the area of conductor for any given number of 16-candle-power lamps, each averaging about eight-tenths of an ampere. Substituting

$$\frac{8N}{10}\text{ for } C,\ N \text{ denoting number of lamps,}$$

$$\text{Area}=3.6\times LN.$$

These formulæ apply, of course, only to navy standard lamps and to naval wiring specifications.

Most of the fittings in use aboard ship are figured in General Information Series, No. XI. A few others are shown in figs. 2 and 3. Fig. 2 is a receptacle for search-light leads, being placed near the projector. Its use is not universal, as the leads may, in many cases, lead unbroken

to the switch in the control stand or pedestal. Fig. 3 shows the stuffing boxes used in carrying wires through water-tight bulkheads or decks. The small one is the ordinary bulkhead tube. The one on the left is for ordinary decks, the right hand one being for protective or other curved decks. The length is necessary to pass through the planking. All these tubes are of brass, lined with hard rubber tubing.

SEARCH LIGHTS.

Several kinds of search lights are now in use in the service. The *Chicago*, *Atlanta*, *Boston*, *San Francisco*, and some others are fitted with apparatus of French manufacture; later cruisers received projectors made by the Thomson-Houston Company, while those finished within the last year are fitted with Thomson-Houston projectors of still another type.

The Mangin projector, as originally manufactured by Messrs. Sautter and Lemonnier, of Paris, was admirably designed and constructed for the conditions of use on shipboard, and but few improvements in the general plan have since been made. It is desirable to have the projectors used in our service of American manufacture, and the Thomson-Houston Electric Company have, for several years, supplied good apparatus. The principal trouble has been with the mirrors, great difficulty having been experienced in making the silver permanently adherent to the glass. The manufacturers are now willing to guarantee the silvering, and greater durability is hoped for.

The latest type of projectors, illustrated in fig. 4, are much larger and heavier than their predecessors, and in those respects are not improvements. They include, however, the new principle of electrical control, and the experience obtained with them will be of value. The apparatus is quite thoroughly explained in General Information Series, No. XI, June, 1892, and no further description is necessary.

It has been the practice for several years in the service to connect all search lights in parallel, controlling each circuit from the switchboard, where they may all be thrown on a separate dynamo, or, if desired, may be worked from the same dynamo which is feeding the incandescent circuits. The former practice is generally followed, but is by no means necessary, as the damage done to the incandescent lamps by the sudden momentary changes of voltage, caused by the search lights being thrown on or off, is more theoretical than real. The sudden jumps are of course unpleasant to the eye, and for this reason the use of a separate dynamo is preferable. In action it is intended with plants of the latest type to operate all dynamos in parallel, and the flickering of the incandescent lights in such circumstances is of no importance.

Each search light has its own dead resistance. It has been argued, from economical considerations, that this resistance should be avoided by lowering the potential of the dynamo to that of the lamp, but it has been found that the resistance is of so much practical benefit in the

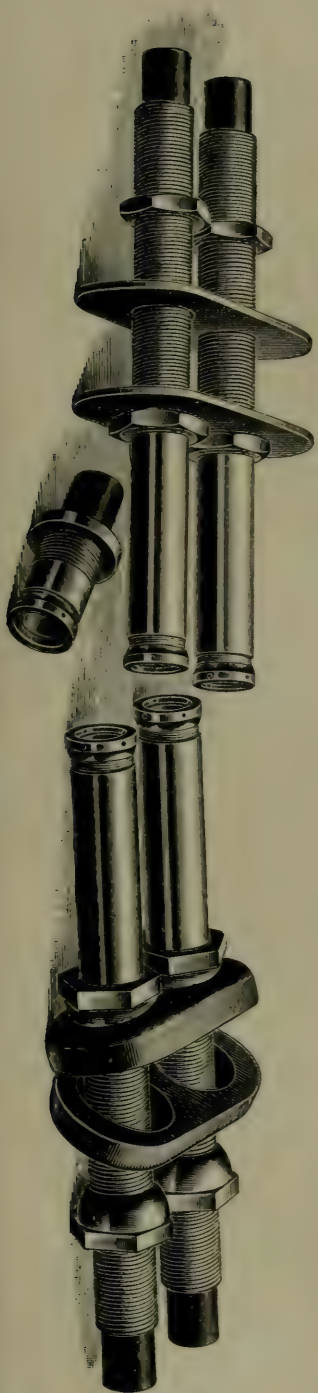


Fig. 3.

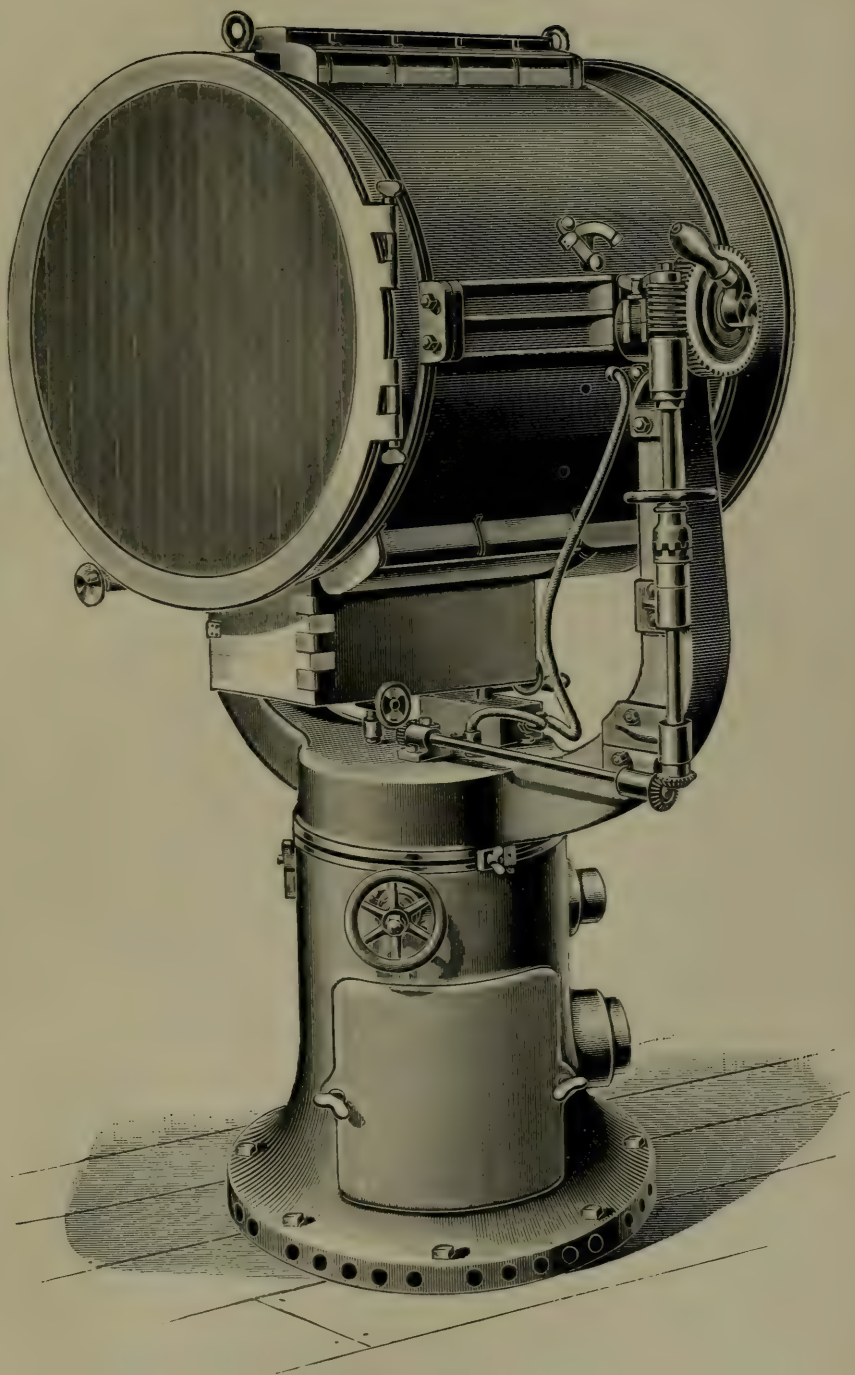


Fig. 4.

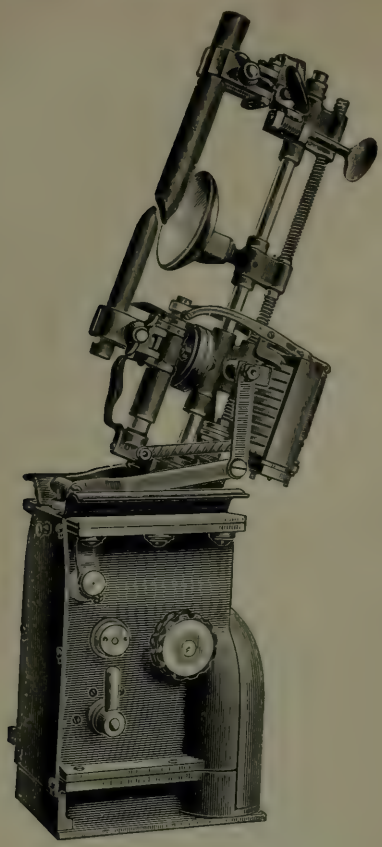


Fig. 5.

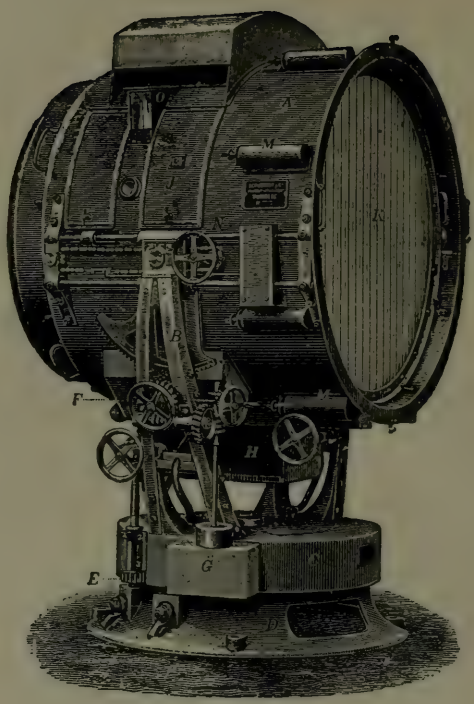


Fig. 7.

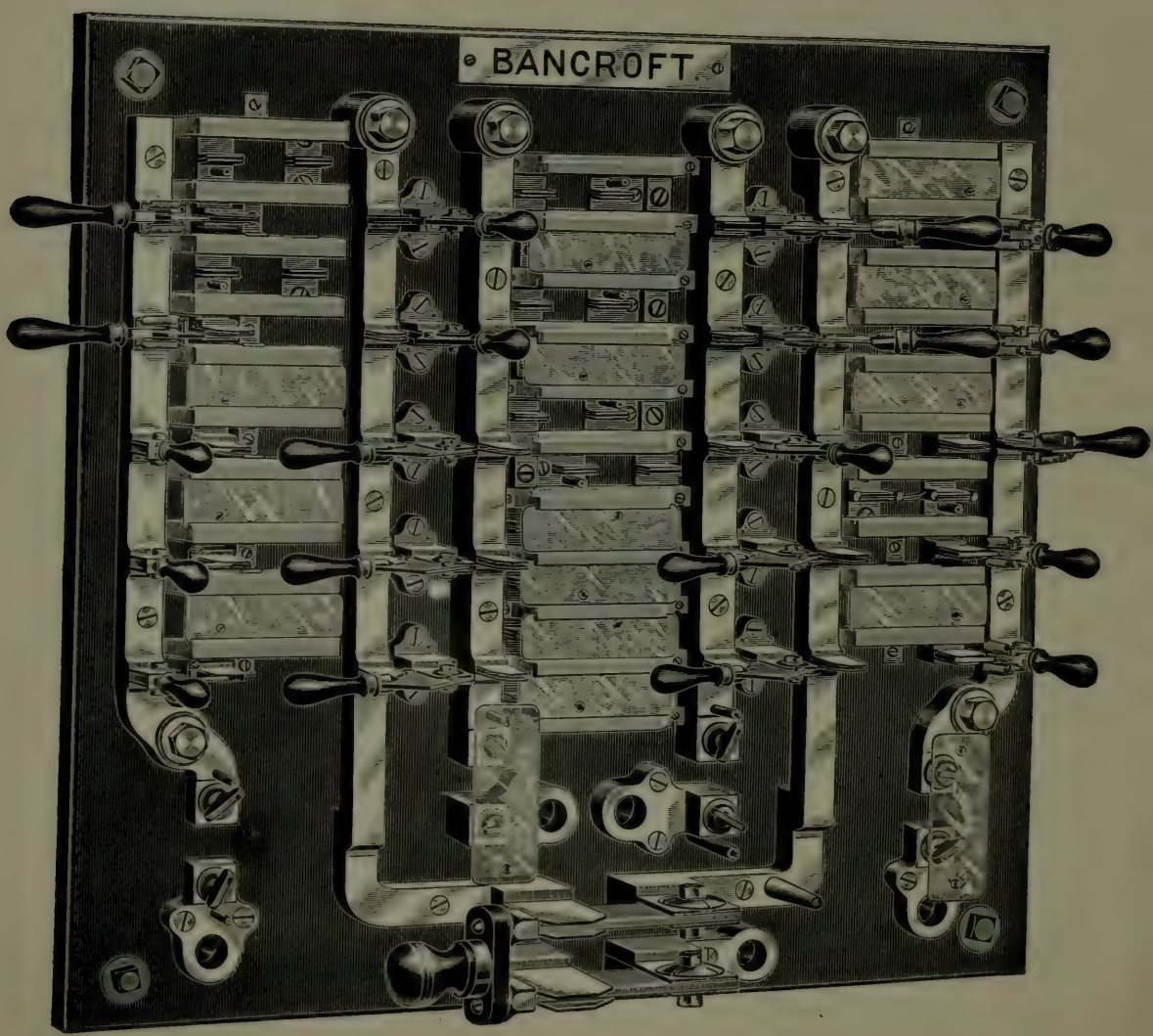


Fig. 8.

operation of the lamp as to make economical considerations less important than those of good working.

In the operation of arc lights carrying the heavy currents now used, the simplicity of Ohm's law is widely departed from, and the sudden variations of resistance, due to the change of position of the arc or to impurities in the carbons, defy all permanent adjustments. Under these circumstances, the dead resistance acts somewhat like a buffer, diminishing the effect of the change and affording a working margin of potential. Any arc lamp operates to better advantage with dead resistance in circuit, and, this being the case, it is true economy to waste sufficient energy to secure good operation.

The best results with search lights will always be obtained with the hand lamp. It requires but little attention from an operator to keep the crater in an inclined lamp well shaped and placed, but that little attention is necessary, and no automatic mechanism can take its place. The latest type of automatic lamp furnished our ships, shown in fig. 5, works as well as any inclined lamp in use in other navies, but when the best results are desired must be controlled by hand. The two great difficulties that automatic action cannot control are the shifting of the crater into unfavorable positions and the "mushrooming" of the arc or building up of an obtuse point on the end of the negative carbon, which masks the crater. The operator adjusts the carbons to keep the crater turned full towards the mirror, and gets rid of the mushroom by bringing the carbons together and breaking it off. In an automatic lamp the mushroom grows slowly, cutting off much of the crater radiation and causing the crater to form too near the end of the carbon. The arc adjusts itself to the potential for which the lamp is set, and may operate steadily under the conditions stated until the mushroom suddenly falls off, causing an immediate lengthening of the arc, which is generally attended with the extinction of the light.

In spite of these difficulties there are certain advantages in the automatic lamp which recommend it, although no type should be used that can not also be worked by hand. There are frequently cases where the search light may be needed suddenly, as with a man overboard, vessels sighted, or danger reported by the lookout. Under these conditions it is a great convenience to have a lamp ready for operation by turning a switch.

The difficulties experienced with the inclined automatic lamp are largely overcome by placing the carbons in line horizontally in the axis of the projector, the crater of the positive being in the focus of the mirror. Left to itself in this position, the upper part of the crater is consumed by the flame of the arc which rises vertically, causing the crater to become inclined upward. This can be avoided in several ways, the simplest being to place a semicircular bar of soft iron of about 2 inches radius below and at right angles to the arc and concentric with it. This iron becomes magnetized by the lines of force of the

current, and reacts on the arc, keeping it down in place and preventing the deformation of the crater. The objection to the horizontal lamp is that the middle of the mirror is inoperative, the crater radiation being cut off by the negative carbon. The diameter of the latter can not be reduced beyond a certain point, nor can the length of the arc be increased, so that considerable loss of reflecting surface is inevitable. Experiments have been made on horizontal lamps, resulting very favorably when working automatically, and it is probable that apparatus of this type may be issued to the service for trial.

The control of projectors from a distance by means of electricity has been tried in foreign services, and several of our ships will have this system installed. The *New York* has four 30-inch projectors, all operated from the forward bridge. It has been claimed that a great advantage is gained by having the observer at a distance from the projector, as his eyes are not dazzled by the glare, and he may thus be capable of seeing faint objects which he might miss if nearer the light. For navigation purposes also it might be a great advantage for an officer on the bridge to be able to throw the beam wherever he wishes without the delay or uncertainty involved in transmitting orders. The objections to the system are, however, serious. The first is the necessity for having two commanding positions for each projector, as unless the beam of light can be thrown to any quarter and followed everywhere by the observer no advantage is gained. It is very difficult on most of our ships to obtain good positions for the projectors alone. The control stand must have some protection afforded from the weather, and yet, if housed in, the view of the operator becomes restricted. If it is necessary for him to operate by commands received from another, the advantage of electrical control is lost, as the orders could be given with equal facility by word of mouth, voice tube, or telephone to an operator at the projector itself. The second objection to electrical control is in the complexity and weight of the mechanism. The weight of each projector and its accessories aboard the *New York* is about 1,980 pounds, and although this will be reduced in future manufacture, the the weight would probably be as great as that of two hand projectors occupying the positions of search light and control stand. The control mechanism is complicated, liable to injury, and difficult to repair with the facilities aboard ship, involving also considerabe expense in installation.

It will have to be determined by experience whether the advantages of electrical control from a distance are sufficiently great to compensate for the increased expense and complexity, the extra weight involved, and the double space occupied.

In working the new type automatic lamps but few precautions are necessary. When used automatically the lamp should always be left in good order after use, with a well-formed crater, the carbons properly placed and in contact, and the spring adjusting the potential at proper

tension. A good light will then be obtained in a few seconds after switching on the current. In working automatically much better results will be obtained by having an operator in position to inspect the lamps and correct any fault that may cause a serious diminution of light. When working entirely by hand, the carbons can be brought into contact without risk of any injury to the dynamo, as the series magnet of the lamp immediately separates the carbons striking the arc. The carbons should not, of course, be held together when the current is on.

The Mangin projector was for many years unequaled in the power of the beam it produced. Many other kinds had been tried, but none could compete with it successfully. The Mangin has the advantage of having both its surfaces sections of spheres, and the spherical curves greatly facilitate the process of grinding and polishing. The mirrors have considerable thickness, supplying the strength necessary in service. The principal disadvantage is the fact that the mirror subtends a small solid angle at the focus, and that much light is lost by falling on the projector barrel instead of on the glass. Recent mirrors have a shorter focal distance.

Parabolic mirrors furnish theoretically the simplest type for search-light use, but glass parabolas are difficult to construct, and metal reflectors are worthless from the rapid deterioration of the reflecting surfaces. Recently Schuckert, of Nuremberg, has succeeded in making parabolic glass mirrors with a sufficient degree of accuracy for search-light work, and has for several years supplied all used in the German navy, besides furnishing a large number to other governments. The Schuckert mirror is a parabola, with its two surfaces parallel and silvered on the back, the thickness of the glass being only that necessary to provide strength, about four-tenths of an inch. It is easy to construct a parabola with any desired focal distance, while preserving the relative lightness of the mirror. The makers favor the use of a large mirror with a short projector, the standard size in the German navy being 90 centimeters, the focal distance being either 35, 42 or 45 centimeters. The Schuckert lamp is of the horizontal type, the carbons being in line. The current in the navy 90-centimeter projector is either 120 or 150 amperes, with a difference of potential of 60 volts at the arc. The positive carbon is 38 millimeters in diameter, the negative 26, and the length of the arc about 18. The projector is fitted with double diverging lenses, by which the divergence of the beam may be varied at will, and is generally arranged for electrical control from a distance. The lamp can be operated either automatically or by hand.

It is to be hoped that the Schuckert projector may soon be given a practical trial in our Navy, to determine its relative efficiency under service conditions when compared with the Mangin. Theoretically the parabolic mirror has decided advantages, but it is probable that these may be greatly modified by considerations of manufacture and use. The parabola is more difficult to grind and polish, and consequently

costs more, while perhaps more liable to mechanical defects than the Mangin form. The mirror is most satisfactory when large, but must then be thin to reduce the weight, and is thus rendered more liable to injury. These points could, however, be waived if it were conclusively shown that the Schuckert projector was more powerful and equally well constructed.

Avoiding any theoretical discussion, it is necessary here to only illustrate the difference between the mirrors, leaving all questions of utility to be determined by trial. Fig. 6 shows two mirrors of the same diameter, one Mangin and the other Schuckert, the focal distance of the former being twice that of the latter. A horizontal lamp is used and

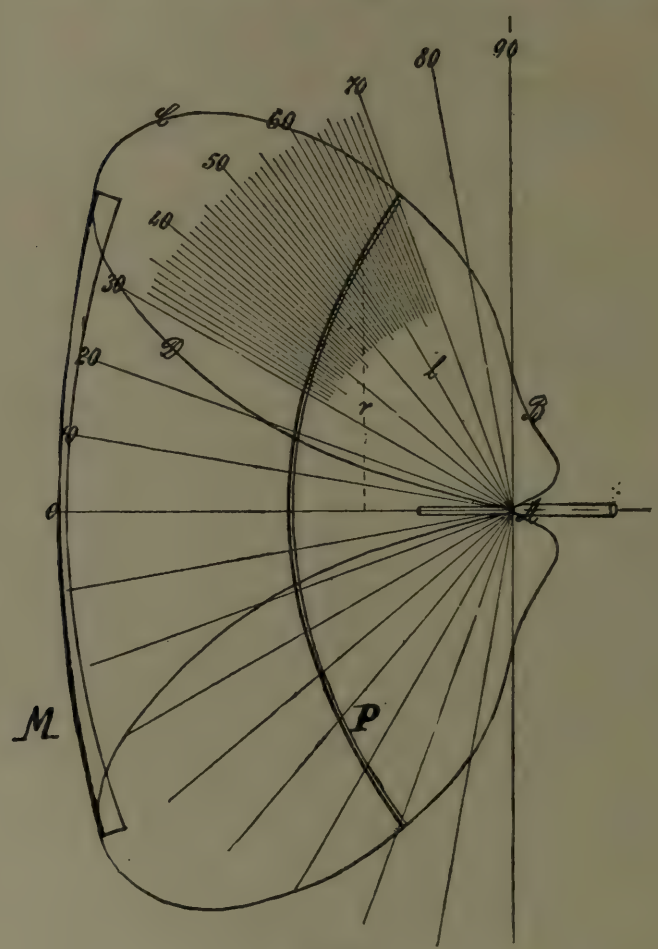


FIG. 6.

the radii of the curves show the intensity of the light on each angle. As drawn, the parabolic mirror *P* practically receives all the light radiated from the arc, while much less falls on the Mangin mirror *M*. In order to make the latter effective it must be brought nearer to the focus, but as there is always a fixed relation between the radii of curvatures of the Mangin mirror, the refractive index of its glass, and the focal distance, the latter can be varied only within limits without sacrificing the desired concentration of light. The Schuckert mirror, on the contrary, can be made with any desired focal length, the concentration becoming only slightly less as the focal distance is decreased.

The limit is found in the practical considerations of leaving room for the negative carbon of the lamp, and of not overheating the mirror. In practice the 90-centimeter Schuckert projector, using a current of 120 to 150 amperes, has about the same focal distance as the 60-centimeter Mangin, using 75 to 90 amperes. The solid angle, subtended by the mirror at the arc, is always greater with the parabolic form, and other things being equal, the amount of light reflected is greater.

Another point already alluded to, on which practical tests are very desirable, is the relative efficiencies of inclined and horizontal lamps under service conditions. The latter seem to offer great advantages for automatic use, as the action of the lamp is better and the movement of the crater on the positive carbon less when the carbons are in line than when they are displaced, as in the inclined lamp. The artificiality of the latter arrangement almost precludes any automatic working. If the horizontal lamp is used it gives the parabolic mirror another advantage, as the focal distance of the Mangin mirror is comparatively so great that much of the surface is in the shade of the negative carbon and is useless as a reflector.

Fig. 7 shows the type of electrically controlled 90-centimeter projector in common use in the German navy. In the latest type there is less gearing, and most of it is concealed in the base.

There is probably no question of naval outfit in a more unsettled condition than that of the utility of search lights. It may safely be said that most officers think they are more trouble than they are worth, and yet when a decision must be made, few, if any, would advocate their abolition. The fact that they are retained in every principal navy in the world is proof that they are thought to be a necessity. The uncertainty as to their advantages is probably very largely due to the fact that officers obtain but little experience in their use as military weapons. The weekly practice is generally confined more to a test of the actual condition of the apparatus than to solving any of the tactical questions involved.

Lieut. Bacon, an exprienced torpedo officer of the British navy, in a short article published after the manœuvres of 1892, stated the conditions underlying search-light work with exceptional clearness, and no better presentation of the subject can be made than in his own words:

Objects on the water or against the horizon are visible solely by the contrast of their color or shade with that of their surroundings. Were the object exactly similar to its surroundings, naturally it would appear but as part of them and be invisible. In bright sunshine it is impossible to imitate water so exactly in its varying color and shades as to render a boat absolutely invisible upon it; so much light is always present ready to be reflected from all parts of an object that slight variations are easily detected, but at night this is different. Smooth water at night, when lit up by a search light, appears very dark indeed, and naturally so, since to an observer near a projector but few rays are reflected back from the small ripples; the water, therefore, appears almost black. Now place on this an object which also reflects but little light to the observer, such as a "dead" black boat (one painted with black lead), and the contrast between the two is almost *nil;* in fact, so nearly

may the two sets of reflected rays match one another as to leave the boat, though in the center of the beam, practically invisible from the ship. It is not sufficient to merely let the beam fall on the boat, but to see it, it is necessary to produce a distinct difference between the light reflected by the boat and that reflected by the water. This at once explains a very common occurrence to all who have taken part in night attacks; that is, to find your boat brilliantly lighted by a search-light beam, and yet for the beam to pass by harmlessly without the boat being observed by the ship. Nor is this all. Observers on board the ship are, to a certain extent, dazzled by the brilliancy of the beam even when at some considerable lateral distance, since the particles of moisture or dust in the air reflect and diffuse light to a considerable extent, and an effect is produced similar, but, of course, to a less extent, to looking out of a light room into a dark night; the exact extent of the effect is determined by the angular position of the observer from the projector and object. There is yet another effect that limits the distinct vision of an observer near a projector, and that is the fact that when near a projector the rays reflected from an object have to travel back for some distance through the beam; that is, they suffer from considerable interference. The result is that the object appears indistinct. It will be easily seen that all these effects greatly reduce the efficient use of a search light when used to pick up an object if the observer is placed near the projector, as is usually the case on board ship, especially when the object is traveling towards the ship at a high speed. The practical proof of this is shown by the fact that a boat is rarely itself recognized in the first instance at any great distance, but originally attention is attracted to her by her bow wave; that is, the wave of foam, which reflects a comparatively large amount of light and shows up distinctively against the surrounding dark-colored water.

Were the above case, viz, that of detecting boats from a ship by means of a search light in the ship the sole use of that weapon, it might, indeed, be an open question whether the electric beam is any material good in naval warfare, for there is one point which must never be forgotten, and that is that the fact of burning such a light reveals the position of the ship to an attacking boat, when, by an absence of all lights, the darkness of the night might be a more efficient protection. It is this particular case which is the one that correspondents in manœuvres are most frequently brought into contact with, and on it opinion is so much divided that in open water it is probable that no captain would promiscuously use his search light as a method of defense. Happily, however, other occasions arise in war time when the search light is of great value. These may be divided roughly under two heads: (1) Defense of a fleet in close waters, where the position of the anchorage water of itself reveals the probable position of the fleet; (2) fleet action at night, or action between single ships.

Regarding (1) the case may be briefly stated as follows: Ships are at anchor in a close anchorage for some particular reason, either for repairing or refitting purposes, or else the close presence of a superior force. For it is inconceivable, considering the deadly nature of a torpedo-boat attack, that an officer would keep his fleet at anchor at night in a harbor that afforded by its position a possibility of an attack from torpedo boats if he could possibly avoid it. Supposing such the case, the search light may be a most efficient help against such an attack. Light may be burned at a distance from the ship on shore to light up the entrance or different sections of the passages through which the torpedo-boats will have to pass, or the ships may illuminate the passages and use observers in their guard-boats. In either case the effect is the same, for no longer has the light reflected from the attacking boats to be reflected at a small angle to the observer, but the observer is placed in a far better position as regards reflection, and far more minute differences in shade can be observed, since the reflected light is much greater. In other words, a greater contrast is produced between the non-reflecting bodies, and the water gun-fire can, therefore, be more effectively used and greater havoc effected on the attacking force.

In such a case one thing is certain—for detecting boats, all beams must be fixed so that observers may get their eyes accustomed to a constant intensity of light, and not a variable one, as produced by "sweeping" beams. This is the most effective use of an electric search light. A few beams may, of course, be kept in reserve for following up and illuminating boats after they have been detected, but these should be quite independent of the fixed beams. The guard boats, some 2,000 yards away, can see the approach of others several hundred yards off, since the surrounding water is well illuminated by the beams of light playing on it. When the boats are discovered, it is necessary to light them up sufficiently for the guns' crews in the ships or boats to use their guns. This may be done by the ships' projectors with divergent lenses in conjunction with parallel beams, the divergent lenses being used to light the boats up, and from their large divergence prevent the chance of losing sight of them again, and the parallel beams to more brightly illuminate them and make them more clear to the guns' crews.

Again, in single ship or fleet action at night search lights must be used to light up the enemy, and now the search light is no longer an objection as showing the position of the ship, since its height prevents an accurate estimation of the position of the water line (the most vulnerable position in the ship to fire at), but in reality it is absolutely safeguard, both since it is misleading as to the distance of the ship and also is blinding to the opposing guns' crews. From the foregoing remarks it will be seen that the function of the search light may be either to discover or to light up an object for guns to fire at. These two different uses are important, since they lead to the height of the light being varied to some considerable extent. It has long been the opinion that for discovering boats the beam should be low, since its direction is parallel to the surface of the water, and therefore lights up a larger area than would be the case if thrown down on the water from a height, when the plane of the water would cut the beam in an ellipse, whose area depends on the inclination of the beam. But a little thought will show that if the beam be parallel to the water the water is but feebly illuminated, whereas a body vertical to the water cuts the beam at right angles and receives a large amount of light. Were the body absolutely non-reflecting, it would be invisible; but if reflecting, a contrast will be obtained. Now that boats can be painted so as to be practically non-reflecting, the low beam is viewed with more disfavor, especially as detection is not the chief function of a light in a ship. The real function of the light on board is to light up an object whose approach has been detected, so that the guns' crews can accurately lay their guns. To do this, it is necessary to keep the light as far from the guns as possible, and also to keep the beam off the water near the ship, so as to prevent the men being dazzled. The best position in the case would appear to be to have the light above the guns, so that the crews practically do not see the beam, except where it strikes the object, and also should the opposing ship use the light to aim at, the shot will be more likely to pass over the ship. Another great point is to have the projectors so placed as not to illuminate any portion of the side or superstructure of the ship; this, again, is best obtained by a fairly high position of the light.

For attacking forts or in action in moderately smooth water, a light in the military tops would seem to answer these requirements; but, of course, with even a moderate motion of the ship a beam from a projector so placed would sweep through a far larger arc than one in a lower position, and would, therefore, be far harder to keep steadily illuminating an object. For navigating purposes, where the water close to and for some distance ahead of the ship has to be illuminated, a low position of the light is best.

A brief consideration of the preceding is enough to show that much of the uncertainty existing in the minds of our officers as to the value of search-lights is due to the fact that no experiments are made to test

the conditions of their efficiency or to develop proper methods of utilizing them. The search-light is a weapon of offense as well as of defense, and requires more judgment and skill in its control than any other weapon entering into the military equipment of a ship. If used at the wrong time it may lead to the destruction of the ship by betraying the exact position to a powerful enemy; if used properly it may save the vessel by depriving an attack of the darkness necessary for its success. Nothing but practice under conditions as nearly as possible simulating those of warfare can give officers clear opinions of how the search-light enters into the fighting power of the vessel. Weekly practices may develop interesting electrical facts as to the light obtainable from heavy currents, but these can be carried on as well from a wharf as from a ship's deck. The many tactical questions, such as how to use the search-lights under different conditions of the atmosphere or of the sea; how to utilize them in case of a vessel at anchor in a harbor; how when lying in an open roadstead; the advantages obtainable by dazzling an enemy and preventing his sighting his guns; the best way of avoiding detection by a search-light; the best method of stationing observers; the practical advantages or disadvantages of electrical and hand control for projectors; the utility of diverging lenses; and above all, the conditions under which search lights should *not* be used, are all matters of the greatest importance, concerning which but few officers have opinions based on experience. A practical investigation of these mooted points is possible aboard almost any ship in commission, and a course of experimental drills would be most valuable in the practical information it would develop.

STANDARD SWITCHBOARD.

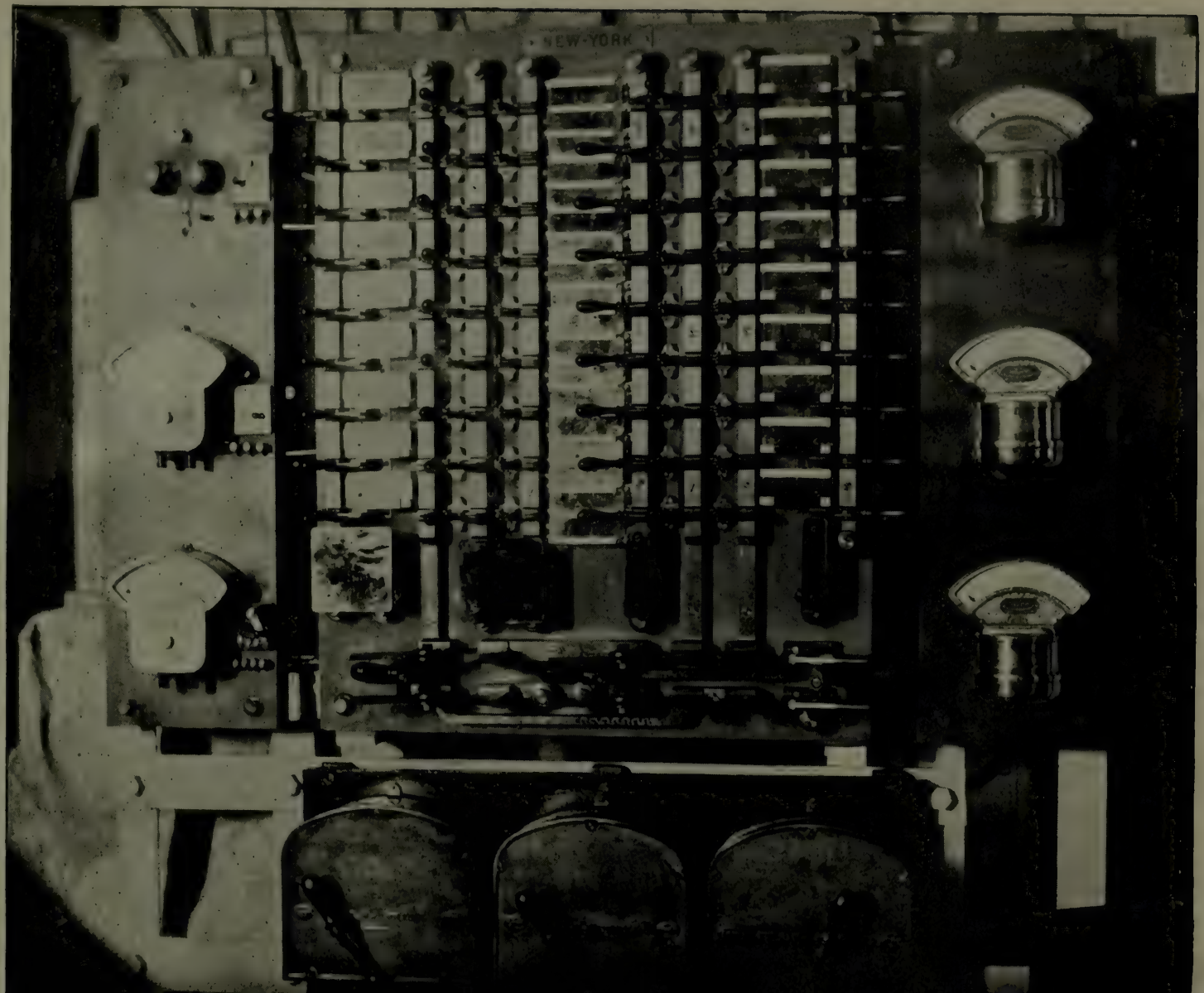
The specifications for the system of switchboard connections have gradually been growing more complex from year to year. In the specifications for the *Columbia* and *Olympia* they read:

> The design to be such that the dynamos may be run either singly or in multiple on the incandescent circuits, either singly or in multiple on the arc-light circuits, and either singly or in multiple on the arc and incandescent circuits connected in parallel.

The standard switchboard was devised to meet these specifications without taking up valuable space.

The switchboard has been briefly described in General Information Series, No. XI, but further details may be advisable. The system is the same, whatever may be the number of circuits or dynamos installed, so that a person familiar with it can operate the switchboard at first sight.

Fig. 8 is the switchboard of the *Bancroft* arranged for two dynamos and ten branch circuits, and shows the most symmetrical and simplest arrangement. Fig. 9 illustrates the switchboard for three dynamos and eighteen branch circuits. The board has on each of its edges a vertical bus bar fitted with fuse clamps and terminals at the lower ends, the two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bars being connected by a cable on the back of the board. The bus bar thus formed is common to all the dynamos, and in practice is connected to the positive terminals. Inside of this bar are the fuses on the positive ends of the branch circuits. On each side of the center of the board there is a set of vertical bars, each set containing as many bars as there are dynamos. The similarly situated bars of each set, counting from the left as No. 1, are connected together by a cable on the back of the board, forming the negative bus bar of the same dynamo. Between the two sets of negative bars are the negative branch circuit fuses.

One-half of the branch circuits are placed on each side of the vertical center line. The positive terminal of each is in the clip near the common bus bar, in which the switch shown in the figure engages. The negative end of the circuit is in the socket, in which fits the shifting plug switch near the center of the board. One of these sockets is placed between each two of the negative bus bars. The plug switch has two small bosses on each side which serve to clamp it in the socket in the open position at right angles to the face of the board. By withdrawing the plug slightly the bosses are disengaged, and the switch may then be thrown to right or left, connecting its circuit to either one of the dynamo bus bars between which it is placed. In a board designed for three or four dynamos the plug switch may be shifted from one socket to another so as to be placed in position to connect its circuit to any bus bars.

The switches for connecting the dynamos in parallel are at the bottom of the board. They are double pole, the upper half connecting the negative bus bars, while the lower half connects the two equalizing bars. The board for two dynamos has only one multiple switch, but those for three or four dynamos have a switch for each dynamo. In the latter case, the upper half of the switch connects the negative bus bar of its dynamo to a common negative bus bar, while the lower connects the equalizing bar of the same dynamo to a common equalizer. It is then necessary to close two switches to connect two dynamos in multiple, the connection not being complete until the last switch is closed. When two or more dynamos are operating singly the multiple switches are open, and hard-rubber guards are placed in the clips to prevent any accidental closing.

As one pole of each dynamo is connected to a common bus bar it can be entirely cut out of circuit only by a double pole switch on the headboard of the dynamo. This switch is therefore a necessity when the standard switchboard is used, and should always be open when the dynamo is not in operation.

All connections are made on the back of the board. Each conductor is soldered to a conical copper plug. The end of this plug has a screw thread tapped in it, and fits into a corresponding conical socket in the bus bar or fuse terminal, being secured in place by a screw inserted from

the front of the board. When this is screwed up, it makes a good and reliable contact.

The design of the switchboard is very simple. All vertical lines are dynamo circuits, all horizontal ones branch circuits, the plug switches being at the intersections. The following directions are from the official instructions:

(1) No metal, such as screw-drivers, monkey wrenches or other tools or watch chains, should be allowed near the front of the board. Any neglect of this kind may cause dead short-circuits.

(2) Putting more than one plug switch on any one section is positively forbidden, as the use of two might put dynamos in parallel without any equalizing bar.

(3) If any section is not wired up, it is advisable to remove its plug switch entirely.

(4) In throwing a section in circuit it is advisable to first place the plug switch in proper position for putting the section on the dynamo desired, and then close the switch on the common bus bar. In cutting out a section, first open the common bus bar switch and then the plug switch. In changing a section from one dynamo to another, it is best to first break the circuit with the common switch, and then throw the plug switch over into proper position and close the common switch. The plug switches are not intended for throw-over switches.

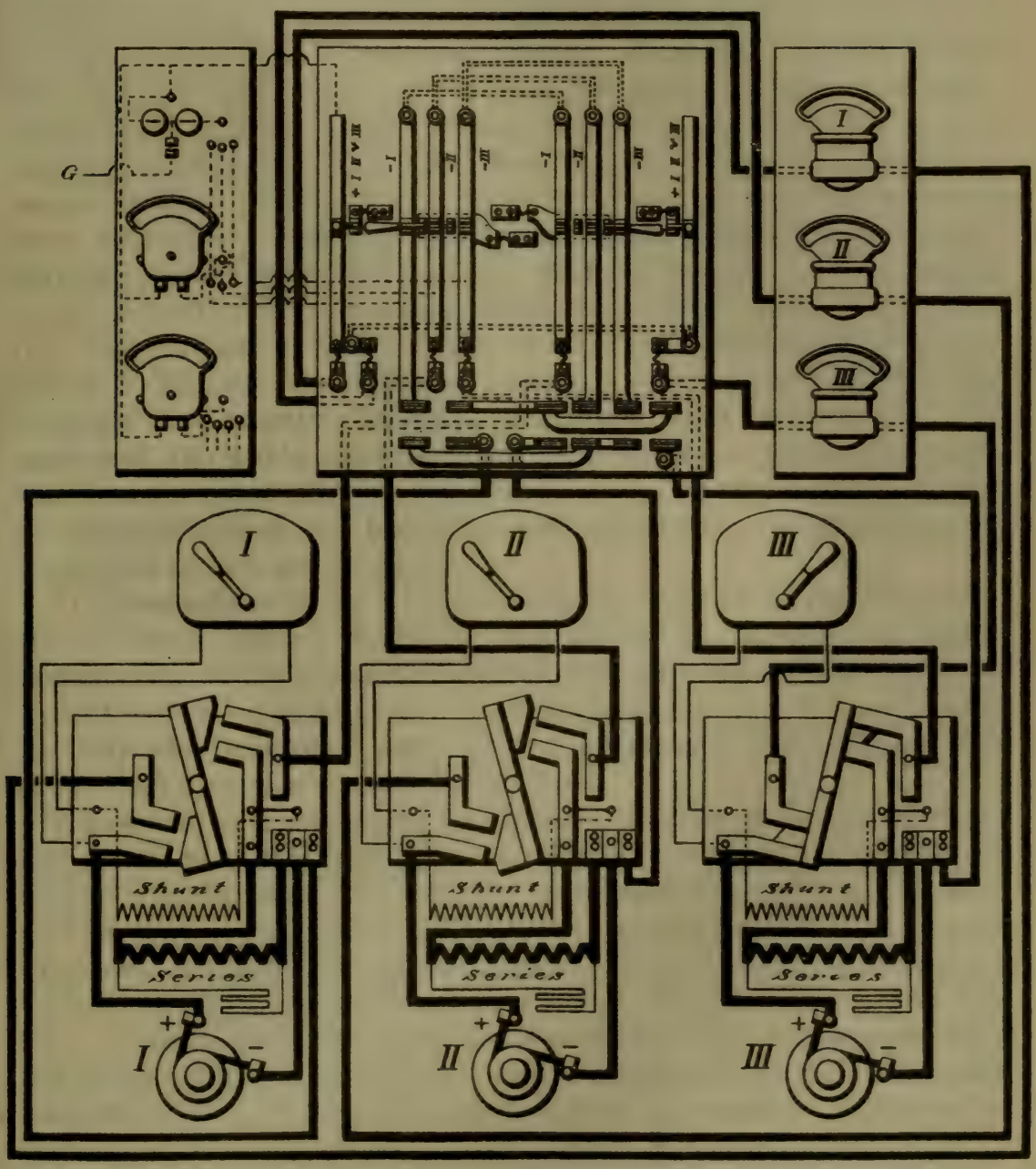
(5) When any section is wired up, but not in circuit, its common switch should be open, and its plug switch open and locked.

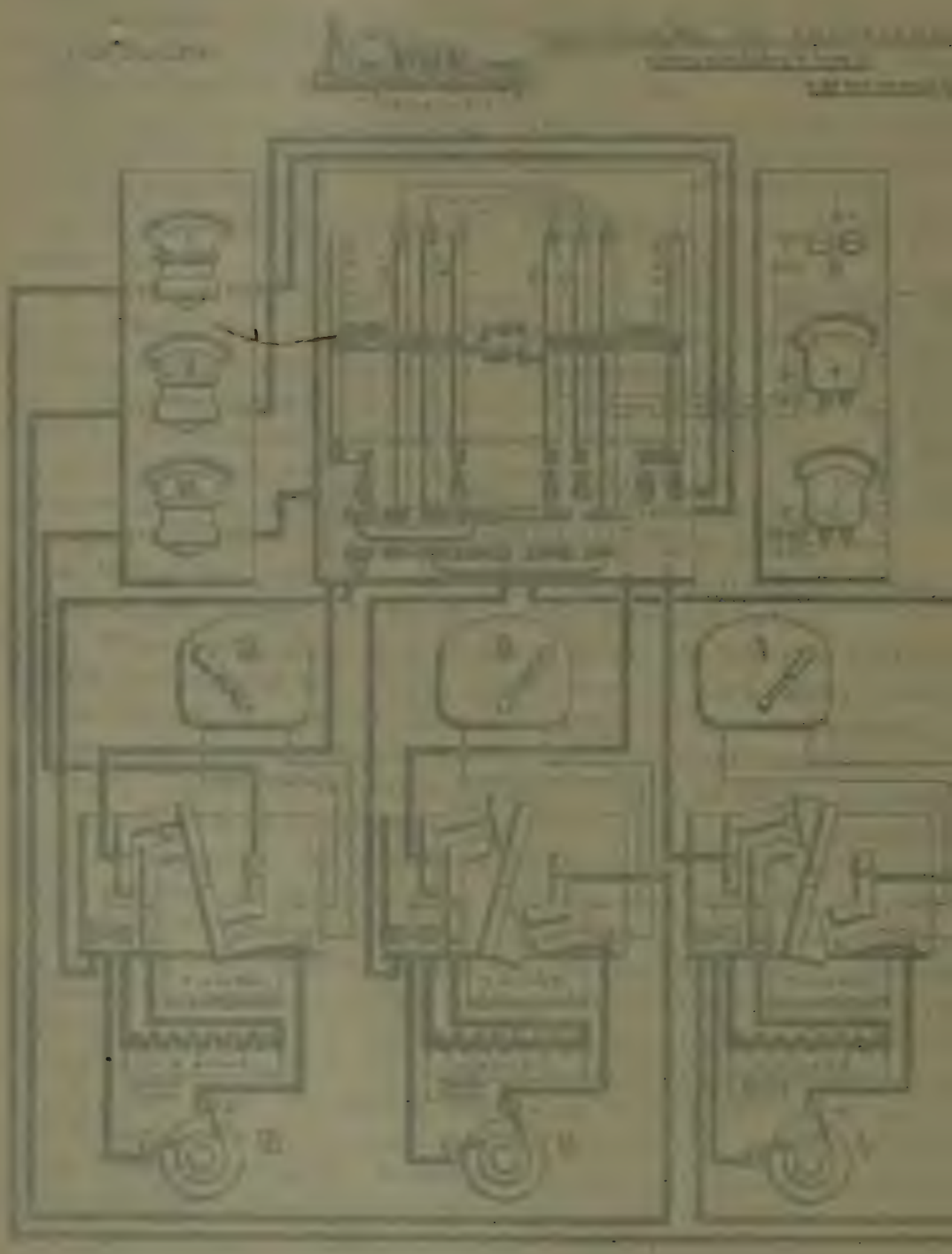
(6) When the dynamos are operating singly the multiple switches should be open and the spring clips covered by hard-rubber covers. These covers to be removed before attempting to connect in parallel.

The standard arrangement of switch and instrument boards is shown in fig. 9. The left hand instrument board carries at the top a ground detector fitted with a multi-throw switch, having as many contacts as there are dynamos. By connecting this with one of the negative bus bars, starting the corresponding dynamo and throwing any plug switches on the same bus bar, each and all branch circuits can be tested for grounds, or an existing ground may be speedily localized. On the middle of the board is a vertical reading Weston voltmeter. One of its terminals is connected to the common bus bar, the other to a multi-throw switch by which it can be put in connection with any one of the negative bus bars. By moving this switch, the potential of any one of the dynamos may be measured and the polarity also tested, the voltmeter needle showing the direction of the current in the instrument. This voltmeter is always kept in circuit and can be read from a distance. The lower voltmeter is connected so as to give the difference of potential at the terminals of the search-lights, having a multi-throw switch with as many contacts as there are projectors. It is identical with the other voltmeter, and is in reserve in case of accident. As its use on the search-lights is unimportant in case of electrical control projectors, it may be used for other purposes.

Connections of Standard Switchboards
3 Dynamos

PLATE I.





Underneath the switchboard are the shunt field rheostats, the left hand being in circuit of the dynamo connected to the left hand bus bar, which in turn is connected to the left terminal of the voltmeter multi-throw switch. The instrument board on the right of the switchboard carries the ammeters, one being in circuit of each dynamo. It is highly desirable that the same system of connections should be followed on all switchboards, to enable persons familiar with one plant to take charge of another at sight. The system shown in Pl. I, has therefore been approved by the Bureau of Equipment. It is, that the same sequence should always be followed from left to right on the negative bus bars, voltmeter terminals and shunt field rheostats, and from top to bottom on the ammeter board. Thus No. 1 dynamo would have the left hand bus bar, left hand voltmeter terminal, left hand rheostat, and upper ammeter; No. 2 dynamo would have the second bus bar, voltmeter terminal and rheostat, counting from the left and second ammeter from the top. A stranger, then, on entering a dynamo room could by a glance at the ammeters see which dynamos were carrying load; the switches on the common bus bar indicate what branch circuits are in operation, while the position of the corresponding plug switches shows to which dynamo each branch circuit is connected. Finally, the multiple switches would show whether the dynamos were operating singly or in parallel, and if the dynamos were numbered, the whole situation could be grasped in a few seconds, and the stranger could operate the plant. At present many ships have switchboards which can hardly be understood with the assistance of plans, and no two are identical.

An examination of fig. 8 shows that the condition of the *Bancroft's* circuits is as follows, neglecting the fact of the absence of fuses. Commencing at the top and numbering the left-hand circuits from 1 to 5 and the right hand from 6 to 10, we have circuits 3, 4, 5, 9, and 10 on No. 1 dynamo; circuits 6 and 7 on No. 2 dynamo; circuits 1, 2, and 8 open; both dynamos operating in parallel.

The operation of compound dynamos in parallel seems to be practically confined to the United States, where it is almost universal in all large power stations. The difficulty encountered in operating in parallel is, that any inequality between the electromotive force of the two dynamos results in the one of higher potential reversing the series field of the other, and driving it as a motor. This is evident, from fig. 10, any current from the upper dynamo to the lower passing through the series coil of the latter in the direction opposite to that of normal excitation. The series field would therefore be reversed. This trouble is easily removed by connecting the brushes of the two dynamos by a conductor of very low resistance called an equalizer, as shown by the heavy dotted line. If, then, the electromotive force of one dynamo becomes higher than that of the other, current flows through the equalizer and through the series field of the weaker dynamo in the right

direction, strengthening it and raising the potential. The vital point of safety in the system is to have the resistance of the equalizer so small that the greater part of the current may flow through it from brush to brush, instead of in the parallel circuit formed by the series fields and the mains. The operation is most successful when the dynamos are similar, but this is by no means essential, dynamos having been operated in parallel whose normal outputs were in the ratio of 38 to 1. The presence of the rheostat in the shunt field is of the greatest assistance. The ammeters are connected on that side of the circuit opposite the equalizing bar, so as to show the total current passing in the external circuit. If, then, one shows very much higher than the others, it is probable that it is feeding them through the equal-

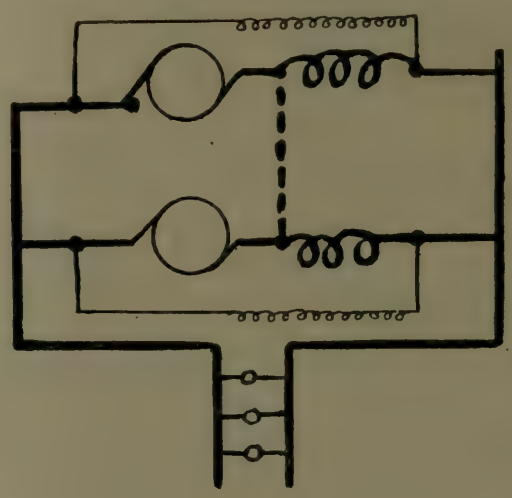


FIG. 10.

izer. A slight adjustment of its rheostat weakens the shunt field, and by reducing the voltage of the stronger dynamo brings all nearer equality. The attendant can, therefore, by an inspection of the ammeters and adjustment of shunt rheostats make each one of the dynamos take its proper proportion of the load, although they differ widely in size, speed, type and output.

The following directions are given for connecting dynamos in parallel on the standard switchboard:

In throwing dynamos in parallel care will be taken to see that each machine is poled right and kept on open circuit until the normal potential is reached before being thrown into circuit. The operation of throwing dynamos in parallel with the naval standard switchboard is as follows: Each dynamo must first be tested separately. It is brought to the proper potential of 80 volts on light load by adjusting the shunt field rheostat. Full load is then thrown on and the voltage should remain the same. If not, it should be adjusted to give the proper voltage by the shunt to the series field. This adjustment should be once made and occasionally verified; too much care can not be given to it, and once adjusted it should not be tampered with. With loads on each dynamo practically the same, and the difference of their potentials less than 1 volt, the multiple switch may safely be closed and the dynamos will work together. Any inequality of load between them may then be rectified by the shunt field rheostats. The polarity of the dynamos

will be shown by these measurements, and, as has been said, should be the same. When one dynamo is to be thrown in parallel with another actually working, it may be advisable to divide the load about equally between them, repeating the observations as to potential before throwing them in parallel.

In explanation of these directions, the polarity of the dynamos is shown by putting the voltmeter first on one and then on the other. The needle should indicate the same voltage on each. If it moves in opposite directions, one dynamo is reversed. Great care should be taken in connecting up the leads and equalizers the first time, to get everything in the right place. Once permanently connected right, no error could ensue except from a reversal of one of the dynamos, and this is shown on the voltmeter. In ships in which the dynamos are frequently operated in parallel, it might be well to connect the lower voltmeter on the instrument board to the equalizers instead of to the search-lights, especially if the latter have individual control stands. In this case, one terminal of the voltmeter would be connected to the common equalizer, and the contacts on the multi-throw switch to the individual dynamo equalizers. The switch should not be closed if there is more than one or two volts difference between the two equalizer sides.

In order to secure good working with the standard switchboards the equalizers from the dynamos must be large. A safe working rule would probably be to make them of the same cross-section as the dynamo leads.

The standard switchboard for three dynamos is shown in Pl. I, with all its connections, made as authorized by the Bureau of Equipment.

MOTORS.

In General Information Series, No. VII, June, 1888, the writer dwelt at some length upon the advantages attendant on the use of the electric motor on shipboard. Since that time they have been largely introduced in different navies for hoisting ammunition or for training light guns, as well as for ventilation purposes. It is unquestionable that they will come into more extended use for these purposes as well as for others, but a wise policy will limit their use to positions in which they are actually superior to any other type of machine. Thus, it would probably be inadvisable to place electric motors anywhere in the engine or fire-rooms, as the combined heat and moisture would cause speedy deterioration, and in such locations, moreover, the presence of steam pipes is no objection. One of the most promising immediate applications of the electric motor is in the operation of ventilating fans, and this problem is now under consideration. The presence of steam pipes always carrying live steam is a nuisance on a berth-deck, directly affecting the health and comfort of the whole crew. In some of the very best and latest ships of the Navy, however, the ventilating fans are placed on the berth deck and are driven by steam engines supplied with steam through long leads of pipe. This method heats the living

space of the crew more than it cools it. From a military point of view it is vitally weak, the whole or a greater part of the ventilating piping, on which the fighting parts of the ship must depend for air in action, being wholly unprotected against machine-gun fire which would riddle the pipes, utterly destroying the ventilation system. In some ships, moreover, immense air ducts are carried through the coal bunkers, displacing a hundred or more tons of coal and cutting up the remaining space so as to greatly interfere with coal passing. Nor can it be considered good policy to cut holes 2 or 3 feet in diameter in water-tight bulkheads, even if they are protected by automatic valves. The system thus outlined seems to interfere both with the military efficiency and the sanitary well-being of the ship. If it were necessary it could be tolerated, but every objection noted can be overcome by the use of electric motors, with a probable gain also in efficiency and weight. The general method will be outlined only.

The system would be to ventilate each compartment between main water-tight bulkheads independently, placing in each two small electric ventilating blowers. These could be used as either exhaust or supply at will. The advantage of placing the blower in the compartment to be ventilated is that no injury to the piping above can cut off the supply of air, as air now enters through any holes in the pipes instead of escaping. A general feed pipe might run fore and aft on each side of the berth deck, from which all vertical pipes leading to lower-deck compartments could lead, the feed pipe being connected to the outer air by ventilators placed where convenient. This method prevents heating of the ship by steam fans, saves water-tight bulkheads and coal bunkers for their legitimate uses, secures ventilation of magazines and fighting spaces in action, and would probably be fully as efficient both in actual ventilation and in the energy required to produce it. It can not be carried out with steam fans, the necessary network of hot pipes heating the ship beyond endurance, but the electric motor will work in any place in which it can be set up, and neither in itself nor in its connections gives off any perceptible amount of heat.

Fig. 11 shows two ventilating fans operated by electric motors, supplied by the General Electric Company for the *Oregon*. The motors are ironclad, the coils being wholly inclosed. A few slight changes were recommended in construction, but the general operation was very satisfactory.

One motor was connected to a Sturtevant exhauster No. 3, the whole set weighing 254 pounds and supplied 1,320 cubic feet of air per minute at the nozzle, at a speed of 1,520 revolutions. The energy consumed was 10½ amperes at 80 volts, or 840 watts. The other motor was connected to a Sturtevant exhauster No. 4, the whole set weighing 446 pounds. It supplied 2,050 cubic feet of air per minute at the nozzle, at a speed of 1,540 revolutions per minute, taking 21 amperes at 80 volts, or 1,680 watts. Both motors were series wound and started with-

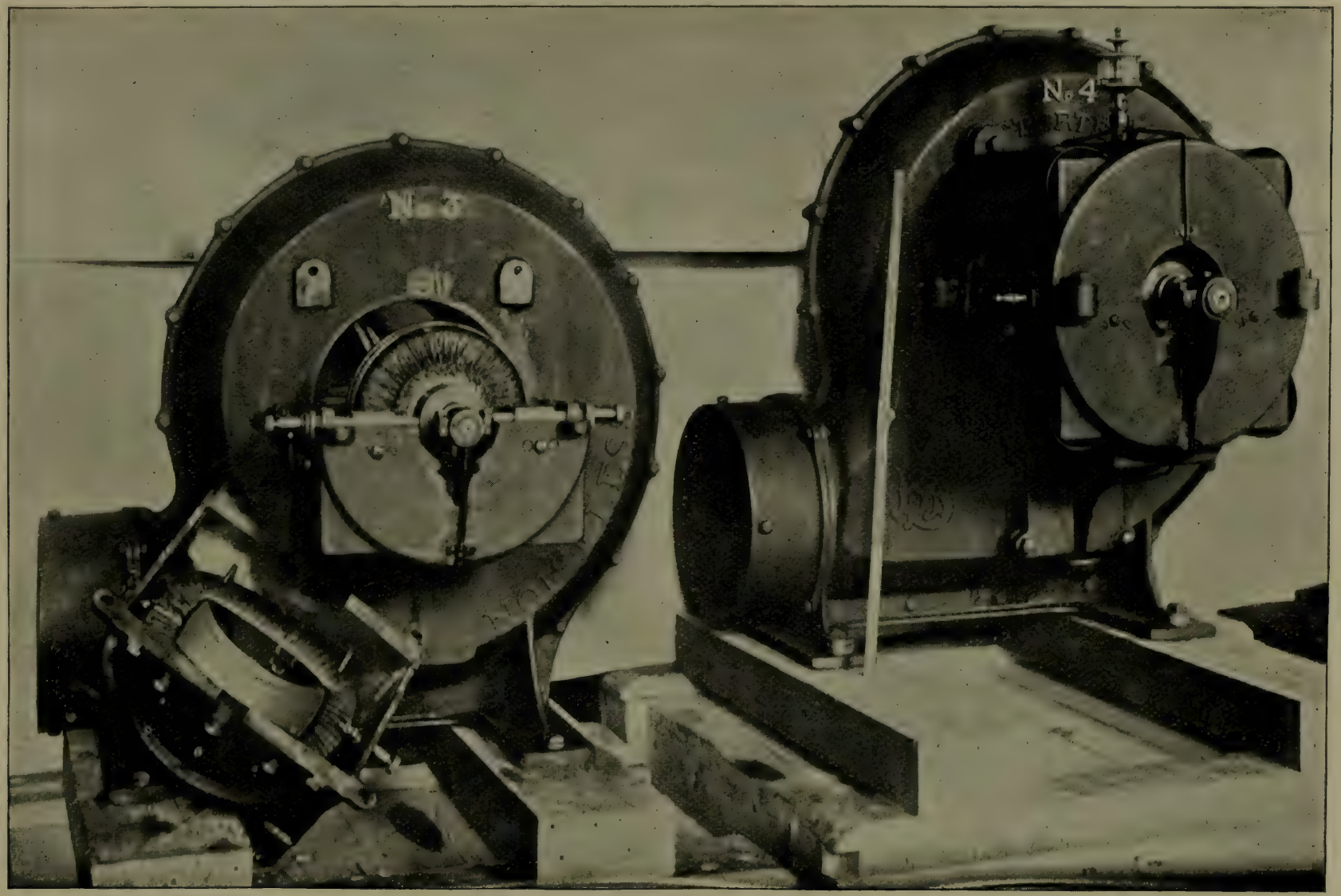


Fig. 11.

out any starting rheostat. The speed of the motors would, of course, be higher and the delivery of air smaller if piping was connected to the exhauster.

If problems presenting themselves in naval construction are impartially considered, it will be found that the electric motor has an unquestionable field of usefulness on shipboard. Much conservatism has been felt in relation to the use of untried or experimental machinery, but the electric motor can no longer be thus classed. Its widely extended use during the last few years, and the durability and general good working it shows under most unfavorable conditions in shore practice, are guarantees that it can be made reliable on shipboard.

It may not be amiss to consider the subject in the light of our necessities.

All motors on shipboard will naturally fall under the head of constant potential motors, supplied from the ship's mains, and either series, shunt, or compound motors may be used. The series motor is valuable for its great starting torque, but has the disadvantage of an irregular speed. In many cases, as in training guns or in other heavy work, steady speed is of no consequence, while the ability to start with a heavy load is all essential. For work of this kind the series motor is the best. If thrown in circuit directly across the mains it might burn out, the resistance being so low as to allow of an enormous current passing when the motor is at rest. As soon as it commences to move the current is reduced to safe limits by the counter-electromotive force. It is advisable, however, to interpose some resistance to save the motor, this being generally in a starting rheostat, the speed of rotation when once in motion being similarly controlled by resistances. An objection to the series motor is the fact that the speed rises dangerously high if the load is thrown off, the excitation being diminished by the rise of the counter-electromotive force of the motor. The motor makes the vain attempt to attain a speed at which its counter-electromotive force equals the difference of potential of the mains, each increase of speed diminishing the field current and counter-electromotive force and calling for higher speed to attain the voltage of the mains. Theoretically, the speed of the series motor under such circumstances is infinite, but the practical limit is found in the fact that friction and internal losses always make something of a load, so that no moter ever runs absolutely light.

The shunt motor, when made with low armature resistance, preserves a practically constant speed with wide variations of load. It possesses, however, the great defect of having no starting torque. The field coils and armature being in parallel, the former are short-circuited by the latter, and if the motor is suddenly thrown into circuit, the field would not receive enough current to magnetize it, while the armature would probably be burned out by the excess of current passing. Some special starting device is therefore necessary, and a starting rheostat is com-

monly provided, by which a current is passed through the field coils before the armature circuit is closed at all. The next step is to send the current through the armature in series with a resistance, the latter being gradually cut out as the counter-electromotive force rises from the speed increasing. The special purpose for which the shunt motor is adapted is, therefore, starting with a light load and afterwards preserving an approximately constant speed. The starting rheostat is necessary and is objectionable as an extra fitting. There have been many cases in the service where these rheostats have been used in continuous running to diminish the speed of the motor, but not being designed for this purpose they overheat and finally burn out.

The apparent paradox, that the speed of a motor is increased by weakening the field and consequently the counter-electromotive force, must always be borne in mind in considering the speed of motors. The fact that the shunt field remains excited when all load is thrown off keeps the speed down to near its normal value. If the speed could increase, the field being kept constant, the counter-electromotive force of the armature would rise until it reached the potential of the mains. It could, of course, go no higher without running the generator as a motor. The actual limit attained is less than that of the mains, as there is always internal loss and mechanical friction in the motor, energy to overcome which must be derived from the mains, and the speed settles at such a point as to allow the motor to receive just this amount of energy.

As the compound dynamo preserves a constant voltage at its terminals with constant speed but varying output, the reversibility of the dynamo and moter would lead us to expect that a motor wound with both series and shunt coils on its field magnets would preserve a constant speed at constant potential with varying load, and such, within limits, is found to be the case. An important difference must, however, be considered. In the compound dynamo, the magnetic effect of the series coil is to reinforce that of the shunt, but if the compound dynamo is used as a motor the series coil will be found to act in opposition to the shunt. While this assists materially in preserving the speed constant when once established, difficulty is found in starting the series coil, which is practically the only one operative when the motor is suddenly thrown into circuit, and tends to start the rotation in the wrong way. As the shunt field "builds" it acts in opposition to the series, and this tendency to rotation in the wrong direction is overcome. It will readily be understood that under such conditions the motor can have no starting torque, and if heavily loaded will burn out. This difficulty may be overcome by *reversing* the series coil, making it co-operate with the shunt coil. This arrangement gives powerful starting torque, and prevents the speed from rising too high when the load is thrown off, but the constant speed is sacrificed, although the variation may be so small as to be unimportant.

The compound wound motor, with both its coils acting in the same direction, possesses therefore the best points of both series and shunt motors, and is advantageous where starting torque and fairly uniform speed are desired, and especially where there is a probability that all load may be thrown off suddenly. If constant working speed is essential, the series and shunt coils must act differentially, the motor being either started light and load thrown on after speed had been attained, or the series coil reversed, as already explained, to gain starting torque, and thrown in differentially as soon as the motor reaches normal speed. This system is complex, requiring an external control board, but answers admirably in such cases as in operating lathes, where constant speed is essential.

The foregoing is sufficient to enable a conclusion to be reached as to the use of motors on shipboard. If starting torque is essential and constant speed is unnecessary, the series motor is the best, an adjustable resistance being inserted as a protection on starting. For purposes calling for constant speed the shunt motor is best adapted, having a rheostat for use only in starting. In special cases the double-wound motor, possessing in a lesser degree the advantages of each of the others, may be best, but it is noticeable that its complexity is preventing its wide use in commercial practice.

A writer in General Information Series, No. VIII, in referring to the use of motors on shipboard, dwells at some length on the disadvantages arising from the increase of dynamo plant, and also on the danger resulting from having all the auxiliary motive power of the ship dependent on the dynamo room. These objections must be considered in any scheme of electrical power transmission on shipboard. The following general plan is suggested for consideration.

Electrical motors will be advantageous—

(1) In all places where auxiliary engines operate continuously for extended periods, the steam and exhaust pipes necessarily passing through store-rooms or living spaces.

(2) For ordnance purposes, where the demands for power are not excessive.

(3) In isolated places, such as military tops, where power is necessary.

Electric motors are inadvisable—

(1) In engine or fire-rooms, where steam is always available, and the conditions are unfavorable for the durability of motors.

(2) In general, where the demands for power are excessive and steam is available, as in the windlass engine.

(3) Where rapid and frequent reversals are necessary, as in the steering engine.

The question of safety of the dynamo plant can be met only by taking all precautions for the protection of the dynamos and wiring, and by operating the dynamos in parallel with a large reserve of power.

If the development of ordnance applications of electric motors should become of great importance, a further guarantee of safety should be obtained by dividing the dynamos between two widely removed dynamo rooms.

COMPARISON OF SPECIFICATIONS.

Not only are different types of dynamo used in different navies, but the methods of operating the plant also vary. In nearly every service the voltage is now standardized at 80 volts, this being a compromise between the high voltage desirable for incandescent lamps and the heavy demands for current made by the search lights. In any case, the type of dynamo and engine actually adopted depends entirely on the specifications to be met. Although those of European navies are not widely published like our own, they are all in print, and no confidences will be betrayed by referring to them.

The British specifications dwell largely on the heating of the dynamo. The common provision is that "at the end of a 6 hours' trial at full load, and 1 minute after stopping, no accessible part of the armature or magnets shall have a temperature more than 30° F. above the temperature of the dynamo room taken on the side of the dynamo remote from the engine and 3 feet distant from it, and that the maximum rise of the temperature of the armature at the end of the trial shall not exceed the temperature of the dynamo room more than 70° F." The wording of these specifications is somewhat peculiar, and the first proviso seems to be utterly inconsequential, as the vital question is certainly not what the temperature is "1 minute after stopping," but rather what it is while the dynamo is in operation. The temperature shown by a thermometer in 1 minute depends as much on the thermometer as on the actual temperature of the hot body, and with the latter remaining the same, the thermometer indications vary with the instruments used. The second proviso, limiting the maximum temperature of the armature to 70° above the air, is definite and intelligible. It is urged that the armature is hotter just after stopping than when in operation, on account of the absence of cooling by the fanning of the air, but as the generation of heat ceases when the dynamo stops, it is difficult to imagine any rise of temperature. Most of the British dynamos have large flat field coils, and in case any curiosity exists as to the temperature of the field coils while in operation, instead of "1 minute after stopping," it can be determined with considerable accuracy by having thermometers strapped on the coils throughout the test, covering the bulbs with waste or flannel. The armature temperature must be determined in the same way after stopping, no other method being available. The following temperatures are from 6 hours' tests at New York navy yard, made on Siemens dynamo built under Admiralty specifications:

Ampères.	Heating of shunt field.		Heating of—	
	In 1 minute.	Maximum.	Series field.	Armature.
	Degrees.	*Degrees.*	*Degrees.*	*Degrees.*
200	21	40	35	46
300	16	33	38	43
400	.....	39	39	35

The British specifications contain many minor provisions, but leave the design and construction of the dynamo almost entirely to the maker. The prevailing type has been for several years the bipolar vertical magnet.

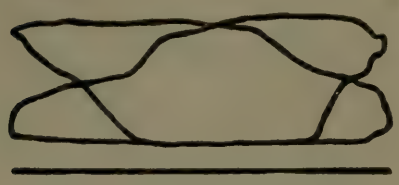
The engine specifications call for vertical, inverted, direct, double-acting engines. These are open, the closed-in types having been abandoned. The most important proviso is that the governor shall be so arranged as to allow the speed to be varied while in operation. This necessitates a throttle governor and causes an absolute sacrifice of what, in the estimation of the American electrician, is the most important consideration, viz, close regulation. Another consequence is the advisability or even necessity of changing the setting of the valves if the working steam pressure is largely varied, or if the exhaust is changed from atmospheric to vacuum. The throttle governor, while able to reproduce a speed after a sudden change of load, can act only when a large momentary increase has taken place. This is, of course, attended with a corresponding rise in the voltage of the dynamo, injuring any incandescent lamps left in circuit. The Admiralty specifications allow a temporary increase of speed or "jump" of 25 per cent.

As this system is almost universal in Europe, it may be of advantage to contrast it with that used in the U. S. Navy. Our specifications allow of a variation of speed of only 5 per cent, when the whole load is thrown off the dynamo, and although this strictly applies to the difference between the steady speeds of the engine loaded and light, it is seldom exceeded even in the "jump." The latter is directly controlled by another proviso that the dynamo voltage as indicated on a dead-beat voltmeter shall not show a variation of more than 10 volts when full load is thrown on or off. This closeness of regulation is obtained by the use of what is commonly known as the "automatic governor," acting directly on the eccentric and changing the throw of the valves, altering the point of cut off, and also adjusting the compression to suit the change of load. No commercial electric-light engine with a governor operating on any other principle could be sold in the United States, while only two naval dynamo engines were seen by the writer in Europe in 1891 that used it. The indicator cards shown in fig. 12 illustrate the capacity of this variety of governor to adjust the working of the engine to variations of steam pressure and exhaust. The reason for the retention of the throttle governor is found in the fact that European dynamos are self-contained, the field circuits

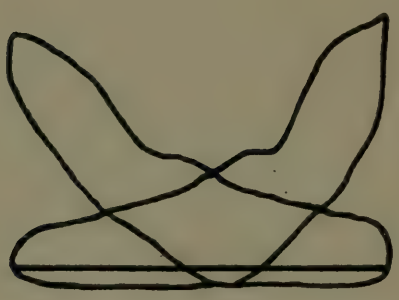
being entirely on the frames. As the dynamo heats the voltage can be adujsted only by an increase of speed. American dynamos, on the contrary, always have an adjustable exterior resistance in the shunt-field circuit, by varying which the voltage may be changed as desired. With a dynamo of this type constant speed is desirable, and automatic engines are therefore invariably used. It is difficult for an electrician accustomed to the facility of adjustment thus obtainable, to conceive

24 K. W. SET, No. 3.

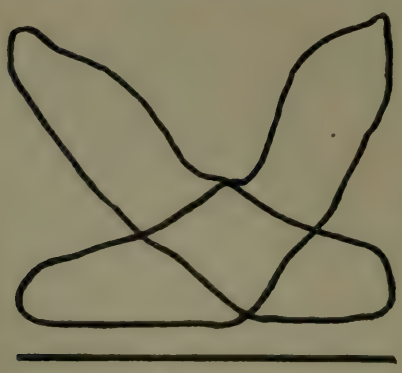
Diameter of cylinder	10¾ inches
Diameter of rod	1⅝ inches
Stroke	6 inches



Spring	50
Steam	40
Vacuum	
Revolutions	393
Volts	80
Amperes	300



Spring	50
Steam	60
Vacuum	27
Revolutions	395
Volts	80
Amperes	300



Spring	50
Steam	80
Vacuum	
Revolutions	399
Volts	80
Amperes	300

Fig. 12.

of any compensating advantages which justify the abolition of the adjustable rheostat. To him nothing is cruder and practically more inconvenient than the method of adjusting the voltage of the machine by setting up with a monkey-wrench on a nut regulating the tension of the governor spring of the engine. Messrs. G. E. Belliss & Co., the principal contractors for Admiralty dynamo engines, have recently constructed automatic engines for commercial marine use, but so far as is known they are not yet used by the Admiralty.

The following table illustrates the difference in regulations between the two types:

	Alexandra.[1]	Crescent.[1]	Colossus.[1]	Miantonomoh.	New York.	Puritan.
Revolutions, full load	312	324	333	397	382	393
Revolutions on throwing off load	395	390	378	411	391	398
Per cent increase	26.9	20.3	13.5	3.5	2.25	1.25
Revolutions, no load	315	327	338	402	389	394
Per cent of change of steady speed	.9	.9	1.5	1.25	1.75	.25

[1] The data for the English ships are taken from Marine Electric Lighting, by H. Cuthbert Hall.

Returning to the Admiralty specifications, another most important proviso is one promoting economy. This is based on water consumption. The contractor, in tendering a bid, guarantees a certain water consumption per hour per electrical horse power, under penalty for each pound of water in excess. The consumption is generally determined by measuring the feed water. This method is apparently superior to the one called for in our specifications of determining efficiency from indicator cards, as it is simple, practical, and not liable to great error. The measurement of feed water checks up any condensation in pipes or cylinders against the engine, and the consumption is therefore sometimes found by a surface condenser, this process, of course, favoring the engine.

The French navy seem to have no standard specifications, the requirements varying for different vessels. The heating proviso, which dominates the whole dynamo design in our own specifications as well as in the Admiralty, is very elastic, the only demand being that it shall be "très faible." This is said to be construed as 35° C. above the air in a 6 hours' run, a much greater limit than our own. The controlling feature in the French specifications is that of economy. As in England, this is determined by water consumption per electrical horse power at terminals. The specifications fix consumption which must be obtained under penalty for every deciliter in excess, a limit being also named, the exceeding of which justifies total rejection. A variation of 2 per cent is generally allowed in the steady speed of the engine between light and full load. The governor must be adjustable while in operation, and this proviso calls for the throttle governor, with regulation of speed by adjustment of the governor. As a result of the above requirements we find the French dynamos to be small and compact and generally operated by compound engines. Many multipolar dynamos are in use, but in recent installation it is understood that the bipolar are preferred.

The tests for acceptance are of two kinds. One is made before the installation of the dynamos on shipboard, generally including two 6-hour tests at full load, one on atmospheric exhaust, and the other on vacuum, each with specified steam pressures. In each case a certain

economy must be attained, penalties being exacted for any excess as above stated. It is understood that the tests of the sets for the *Marceau* gave an economy of 12.2 kilos of water per electrical horse power at terminals, while those of the *Neptune* gave a consumption as low as 11.7 kilos. At these tests all measurements of insulation and copper resistance are made. If the first tests are successful, the sets are installed on shipboard, and when in place are subjected to another continuous test of 24 hours at full load.

Although the French dynamos are not made large by the imposition of a low heating limit, it is noticeable that, in spite of their apparent compactness, they occupy nearly as much floor space as the later American types and are but little, if any, lighter. They are invariably of a high degree of mechanical excellence.

The dynamo apparatus of the German navy is made either by Siemens and Halske of Berlin, Schuckert of Nuremberg, or Kummer of Dresden. Each manufacturer has his own type, most of the recent apparatus having been made by Kummer. One of his types is somewhat like that in use in our service aboard the *Philadelphia* and *Baltimore*, but a later type is a ring frame having six interior poles. Incandescent lighting is subordinated in the German navy to the search light. As the Schuckert projectors in use each take 150 amperes, the practice is to install a 180-ampere dynamo for each projector, leaving but a small margin for simultaneous operation of incandescent lights. The dynamos are never coupled in parallel, and the incandescent lighting is therefore comparatively ineffective. Although the general type of apparatus is much like the French, Kummer has made dynamos having adjustable rheostats in the shunt fields and driven by automatic engines.

The foregoing is merely an outline of the prevailing characteristics of the dynamo machinery in the principal foreign navies. The one point which remains for us to notice is that of economy. More stress is laid on this abroad than in our own service, although our specifications call for a percentage of efficiency taken as the ratio of indicated horse power to electrical horse power at the terminals. It is certainly most desirable to have economical dynamo apparatus, but the question of economy presupposes certain working conditions which have to be met. No engine or dynamo is economical when operating at a fraction of its normal output, or with one-half its normal steam pressure, and yet these are exactly the conditions under which our naval dynamos operate two-thirds of the time. Moreover, economy of working depends mainly on the boiler, and as long as the main boilers are used for generation of steam, the consumption of coal must be excessive for the amount of work done. While these considerations will not justify an uneconomical engine or inefficient dynamo, they indicate that economy of actual working depends on many circumstances, and that it may be better practice to design our machinery with special reference to dura-

bility and good working under the conditions holding on shipboard. This is the policy that has been followed, and although our dynamo engines are probably not as economical as others, they have a margin of power which, in connection with their automatic governing, makes them largely independent of all variations of steam pressure, enabling them to carry their load on half pressure, and, so far as is possible with a high-speed engine, to work with wet steam. Compound engines have been but little used in our Navy although not forbidden by specifications, the increased complexity and the ordinary low working steam pressure rendering them of practically no advantage.

American specifications call for the operation of dynamos in multiple, while in other services it is unknown. The advantage of parallel working is in the fact that it minimizes the effect of injury to any one dynamo. In a ship supplied with gun motors and search lights, the demands made for electrical energy in time of action would vary suddenly and largely, so that it would be impossible to distribute the load on separate dynamos without having great excess of power. In such a system, each dynamo must have a reserve power sufficient to cover all demands made upon it, although nine-tenths of the time it may be working light. This would hold of each dynamo of the plant. By yoking all together, however, we can take advantage of the fact that it is improbable that all motors will simultaneously be working at their maximum, and if not, there is a safe margin of power. The dynamo plant should, however, have an output equal to all demands made simultaneously, and the system of parallel connection would then prevent a total break-down of any motor mechanism from the fact that one or more dynamos may be injured. The advantage of the system is so evident as hardly to admit of question, and the fact that parallel working of dynamos is hardly thought of in any other service than our own must be explained by the difficulty of carrying it out without the automatic engine and the rheostat in the shunt field of the dynamo. Its practicability is abundantly proved by the habitual operation of compound dynamos in parallel in almost every power station in the United States; its military advantages have already been set forth, and justify the use of the method on shipboard.

CARE OF PLANT.

The conditions existing aboard men-of-war are specially trying to dynamo apparatus, and even with the best of care deterioration is more rapid than is usual ashore. The continuous operation of the dynamos, the high temperature of the dynamo-rooms, the presence of salt water and salt air, and the inevitable wear and tear attendant upon the crowded condition of the ships, are all difficulties to be encountered, but intelligent care will materially assist in overcoming them and in minimizing deterioration.

A great part of the trouble experienced on shipboard arises from the

engine. A high-speed engine, especially if working with a small clearance, as in the Armington & Sims type, is specially sensitive to water in the cylinders, and but very little is required to cause a break-down. This danger can be much reduced by careful arrangement of steam and drain pipes. The dynamos are now supplied by independent steam pipes, and these are as straight as possible, and without any drop bends in which water may accumulate. Separators are generally placed in the dynamo-room, but can not be relied upon to prevent all access of water. The engine drains are found to work well on a vacuum if piped directly into the exhaust, but when operating on the atmosphere must be led into traps, special attention being paid to avoiding back pressure. The engine cylinders are fitted with automatic relief valves, but a valve is frequently put in the drain pipes back of these, and, if shut, prevents their action. The dynamo attendants must thoroughly understand the drain piping, and see that the drains are always clear. Care must be taken on starting the engine to drain the pipes and work all the water through at low speed, and as this precaution is obvious, accidents do not often occur then, most of the damage by water being done while the plant is in full operation, and is due to foaming or priming in the boilers, causing a sudden lifting of masses of water into the pipes. Shifting from one boiler to another sometimes causes trouble from water having accumulated in the pipes. Implicit reliance can not be placed in such cases on either automatic drains or separators, and safety requires the slowing of the engines if the noise of water in the cylinders is serious. The Armington & Sims engines in service seem to break the crossheads from the effects of water oftener than any other part. The only accident of this kind, within the knowledge of the writer, happening to one of the new engines, resulted in breaking the piston.

Heating of crank pins and bearings may, of course, be due to the shaft being out of line, or to bad fit of the brasses. The latter is easily remedied; the former is not liable to occur, as every engine is subjected to a run of at least two days before being put in place. If heating occurs in engines which have previously given satisfaction, it is probably due to dirt and grit in the oil cups, or to the brasses being set up too tight. One cause of injury to the plant is frequently found in the lack of mechanical skill of the force. Dynamo engines have been found cut and scarred by the marks of cold chisel and hammer used to start nuts or back out pins, while many parts are upset by hammering. No critizism of such treatment is needed.

The dynamo also requires reasonable care and intelligent treatment. The field coils are liable to have their cotton insulation rotted by moisture or charred by overheating. The former would probably occur only when the dynamos are laid up for a long time. The overheating is, however, an effect of use. One of the most common causes of overheating the field coils is operating at too low a speed, with the mistaken

idea of saving wear and tear on the engine. If the latter is properly designed it will be as durable when worked at its normal speed as at any lower. If the dynamo is below speed a stronger current is necessary in the shunt field coils, in order to maintain normal voltage, and as the heating varies as the square of the current, the variation of temperature is much greater than that of speed. If the field coils be found to overheat, the defect may be diminished by increasing the speed and lowering the voltage if necessary.

Armature bearings give little or no trouble, as there is ample surface and no side thrust on the shaft. The armature itself requires no special attention beyond mechanical protection. This should not be such as to prevent good ventilation of the coils.

The point of most rapid deterioration of the dynamo is the commutator, and nowhere is care more required. Damage to the extent of hundreds of dollars may be done in a short time by allowing the brushes to spark heavily. The commutator segments are now made of hard copper or bronze, and are 1½ inches deep. No material can be used, however, which will stand heavy sparking. The ordinary injuries to the commutator are of two kinds, due to scoring and sparking. If a hard copper brush is used and the springs are set up with considerable tension, the commutator segments are scored and cut by the friction, and everything in the vicinity becomes covered with fine copper dust. The tension should always be as light as possible and regulated after the brushes have been placed at the neutral points. Sparking may be due to a great many causes; in fact, almost any defect in construction or design of the dynamo manifests itself in this way. As all dynamos are tested, however, before being placed on shipboard, and excessive sparking is sufficient reason for rejection in these tests, anything of the kind noted after installation is probably due to some defect which has been developed and necessitates careful inspection to determine the cause. It will, in general, be found to arise from defective insulation on the armature, causing either a heavy ground or a cross. If the defect is on the outside, it may be repaired by covering it with shellacked tape, but if on an inner turn, the coil must be rewound. The Gramme armature, almost exclusively used in the Navy, has the great advantages of not being liable to short circuits, and of being easy to rewind if they do occur. In naval practice, armatures have burned out only from actual mechanical injury ruining the wire, or from general deterioration of insulation due to continous overheating. The first can be guarded against by careful handling and treatment, the latter by avoiding excessive overheating.

There is a great difference in dynamos as to sparking, depending mainly on the strength of the field and on the distribution of the lines of force. Every coil is short-circuited as it passes under the brush, and if it is at that moment generating electromotive force there will be heavy sparking. It is possible to so arrange the field of the dynamo

as to have an electromotive force generated in the coil opposing that due to the short-circuiting, and in this case, the short-circuited coil will be practically dead and no spark occurs. In any dynamo in operation, the standard rule is to set the brushes at the position of minimum sparking. If it occurs on one set of brushes and not on the other, it shows that they are not at the right distance apart, and one set must be moved to bring both at the neutral points. Sometimes the brushes may be too narrow, and it will be found advantageous to spread those on the brush-holder so as to cause them to make good contact on two commutator segments.

Gauze brushes have recently been tried and are found very satisfactory, as, while admitting of sufficient tension for good contact, they do not score the commutator. Carbon brushes are largely used in shore practice in cases where large and sudden variations of load take place. They do not obviate the sparking, but render it less injurious, the brush wearing away instead of the copper of the commutator. They should have a cross section of at least 1 square inch for every 50 amperes to avoid heating.

Once in place, the fixed wiring of the ship should cause but little trouble. The insulation on the wire in the fire-room is apt to deteriorate from heat, becoming harder and more brittle, and therefore more liable to injury. Most of the deterioration in the fixed wiring occurs, however, in the receptacles, switches and junction boxes. Unless care is taken to always have these screwed up tight, moisture or water is liable to find its way inside, where it is held and slowly corrodes the copper of the conductors. Steam-tight globes also are frequently not set up firmly on their rubber gaskets. The standard fittings are water-tight only when care is taken to keep them so; if neglected, water will work in and remain. Portable double conductor wire is sometimes treated by the crew with about the same consideration that they give a hawser and is, of course, rapidly worn out. The latest type is stronger and more durable than that formerly issued, but should have intelligent handling.

Rubber covered wire should not be painted. Many pieces have been taken out of ships in which the rubber had been rotted by the oil of the paint. If different colors are desired, they should be made with colored braid.

The automatic search-light lamps should be occasionally overhauled, a little jeweler's oil on pivots materially assisting their working. The tension of the springs should be occasionally looked to, that the lamps may feed at the proper potential, which varies from 45 volts when using 50 amperes to 52 with 100 amperes. The lamp should always be left with a good crater and with the carbons properly placed. Sufficient experience has not yet been gained with the electrical control apparatus to predict its special weakness in service, although it is safe to say that its complexity is such that reliability can be obtained only by constant care. The

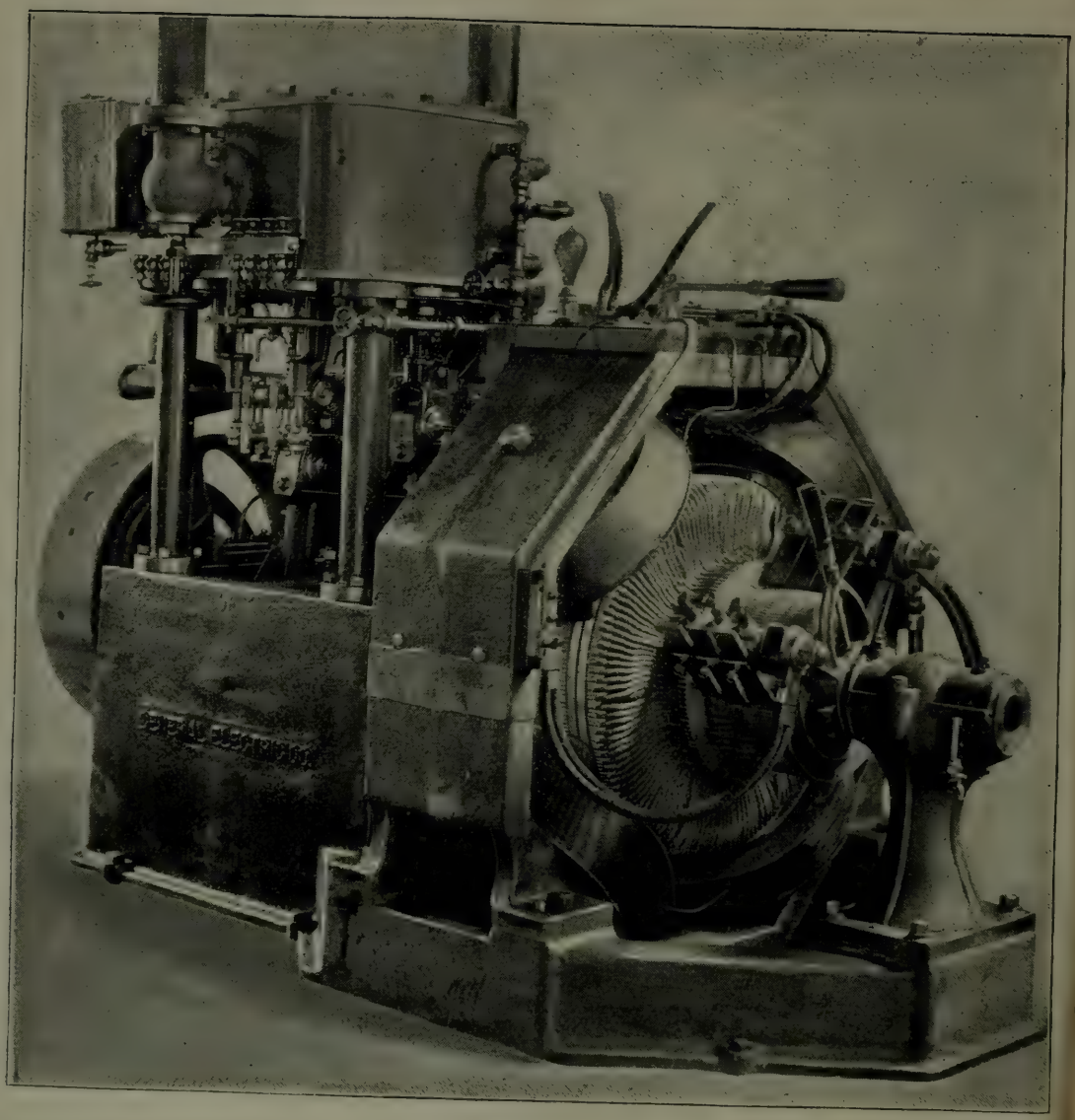


Fig. 13.

search light mirrors should be kept clean, and when working with heavy currents in very cold weather it is probably advisable to keep them protected from sudden changes of temperature. The mirrors are sometimes broken by the blast of the guns, but this will seldom occur if the projectors are placed at a proper distance from the latter. The plane glass doors are more liable to injury and are made in standard strips, any one or more of which can be replaced at little expense.

The indicating electrical apparatus thus far installed in our Navy has not given satisfaction in service, although working well enough in tests ashore. Other systems will be installed for trial, and with care it is hoped will give good results.

The present type of fixtures and many of the fittings are finished in dark bronze. The durability of this finish is doubtful. As it is lacquered it requires no cleaning except an occasional wiping off with an oily rag. Any scrubbing or polishing is liable to rub off the film, exposing the metal underneath.

The care necessary for the proper preservation of a complex electrical plant can be given only by thoroughly trained men. Whatever electricity may do in the future, it will always depend on human intelligence for the full development of its power, and all complex electrical apparatus requires attention to keep it in working order, as well as technical skill for its operation.

ADDITIONAL NOTES.[1]

Since the publication of the article by the Naval Institute some changes have been adopted by the Bureau of Equipment in the type of generating sets for new vessels. These sets are intended to remedy defects which have been determined by test or by experience on shipboard in the type previously furnished. Fig. 13 illustrates a 24-kilowatt set intended for the *Indiana* and *Minneapolis*. The changes are in the stroke from six inches to five, the placing of the governor outside the engine frame, placing the cranks opposite each other instead of at 90 degrees, and in making the engines so that the pistons and valves can be removed from below. The dynamo armature is identical with those formerly used; the field coils have, however, been placed in the diagonal axes of the frame instead of in the vertical and horizontal. If necessary to shift the armature, the upper part of the field frame can be lifted and the armature taken out from above. Difficulty has been experienced in handling heavy armatures of the former type which were keyed to the shaft. So far as experience with this type has gone the result seems to have been very satisfactory. The regulation is as close as in the first engines, while the noise and vibration are much diminished. In one of the tests it was thought advisable to determine

[1] The following notes are, at the request of the Chief Intelligence Officer, appended to the article originally written for the Naval Institute.

the heating of the dynamo on a four hours' run with a load in excess of its normal capacity, and a 300-ampere dynamo was run for 4 hours with 400 amperes. The engine developed sufficient power for the purpose, and the heating of the dynamo was only 50 degrees on the armature and 60 degrees on the field frames, showing the capacity of the sets for overwork.

The following data illustrate some of the improvements made:

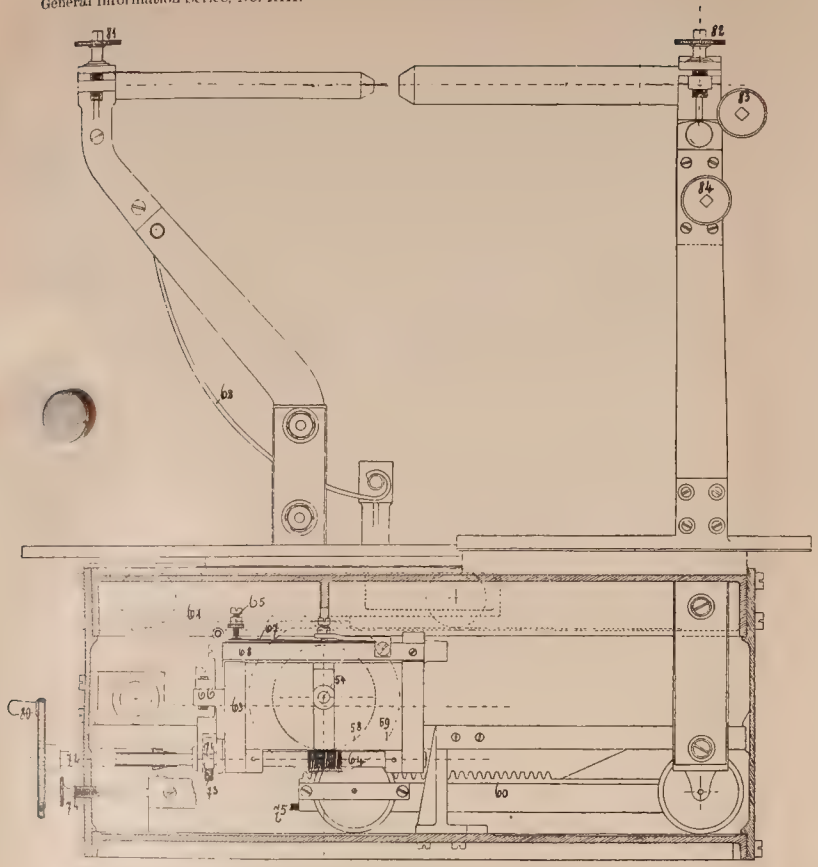
24-kilowatt set.	Ft.	In.
Length over all	7	8
Width over all	3	9½
Height over all	5	5⅝
Weight of—	Pounds.	
Dynamo	4,608	
Bed-plate	1,245	
Engine	2,612	
Total weight	8,465	

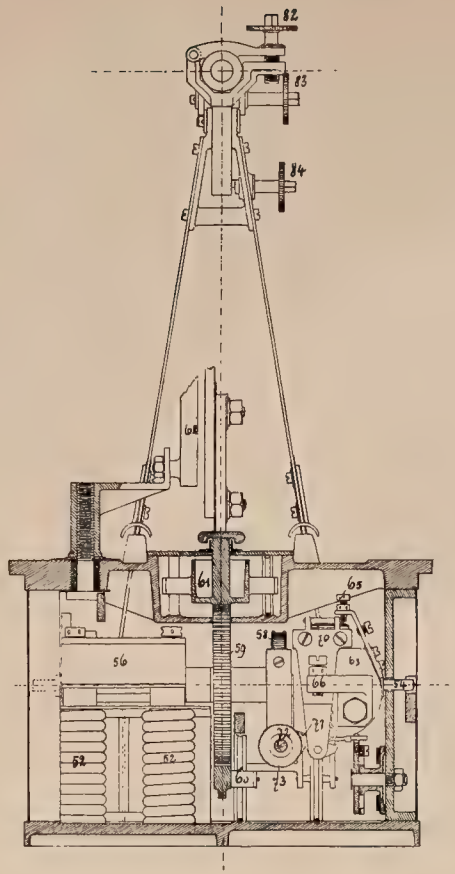
Among the recent changes authorized by the Department is the experimental test of the Shuckert projector, one having been purchased for installation on board the *Maine*. This projector was on exhibition at the World's Fair at Chicago, and is identical with that illustrated in fig. 7; a description of the lamp used in connection with it may be of service.

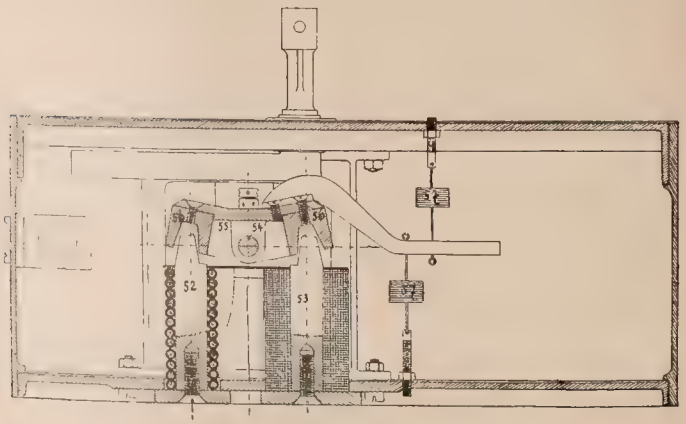
The general appearance of the lamp is shown in fig. 14, in which the sides of the casing are removed to show the interior mechanism. The regulating apparatus is very complex, but is of excellent workmanship and its operation is good.

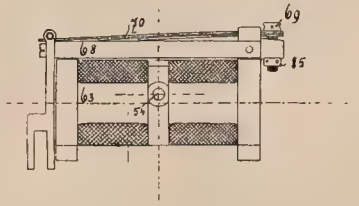
The principle of working is illustrated in Plates ii, iii and iv, which are lettered and numbered the same. The carbon-carriers 60 and 61 engage on opposite sides of a toothed wheel 59, which turns freely on an axis 54, being locked thereto ordinarily by a ratchet wheel and pawl. This axis is prolonged, and on one end has the armature 56, which is balanced by springs 57, over the poles of the two electro-magnets 52 and 53. One of these is in series with the arc, the other, 53, of high resistance, is in parallel with it. When the circuit is closed the coil 52 attracts 56, separating the carbons and striking the arc. As the carbons burn away the influence of 52 diminishes and that of 53 increases, and the consequent movement of the armature 56 being communicated to 54 and 59, brings the carbons nearer to each other. When the lamp is operating with its normal current and at proper potential the armature 56 is horizontal above the two magnets.

To allow for the burning away of the carbons, which would ultimately bring 56 at its limit of motion over 53, in which position no further feeding of the carbons could occur, another high-resistence magnet 63 is also placed in parallel with the arc. Its armature 68 is fittted with a make and break contact spring 67, by means of which the current through 63 is interrupted at every movement of the armature, the intermittent motion thus obtained rotating the ratchet wheel 72 by means of the pawl 71, this motion being continued to the wheel 58 by means of the endless screw 64. The wheels 58 and 59 are permanently connected, and the rotation of the latter separates the carbons until the floating armature 56 reaches its position of equilibrium, when 52 and 53 control the arc until the wasting of the carbons reaches the limits of the action of the latter, when the feeding together is again performed by 63. It will be noticed that the latter and its appurtenances are all connected to the axis 54, the connection between 54 and 59 being formed by the endless screw 64 and the rachet gear 71 and 72.

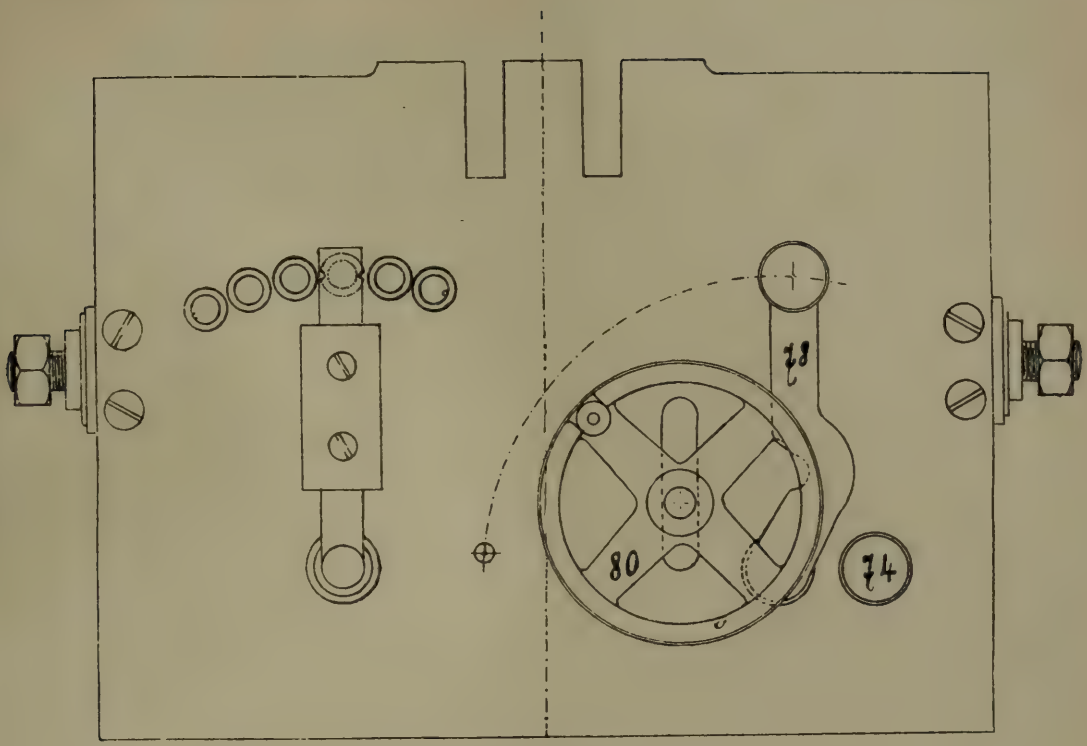




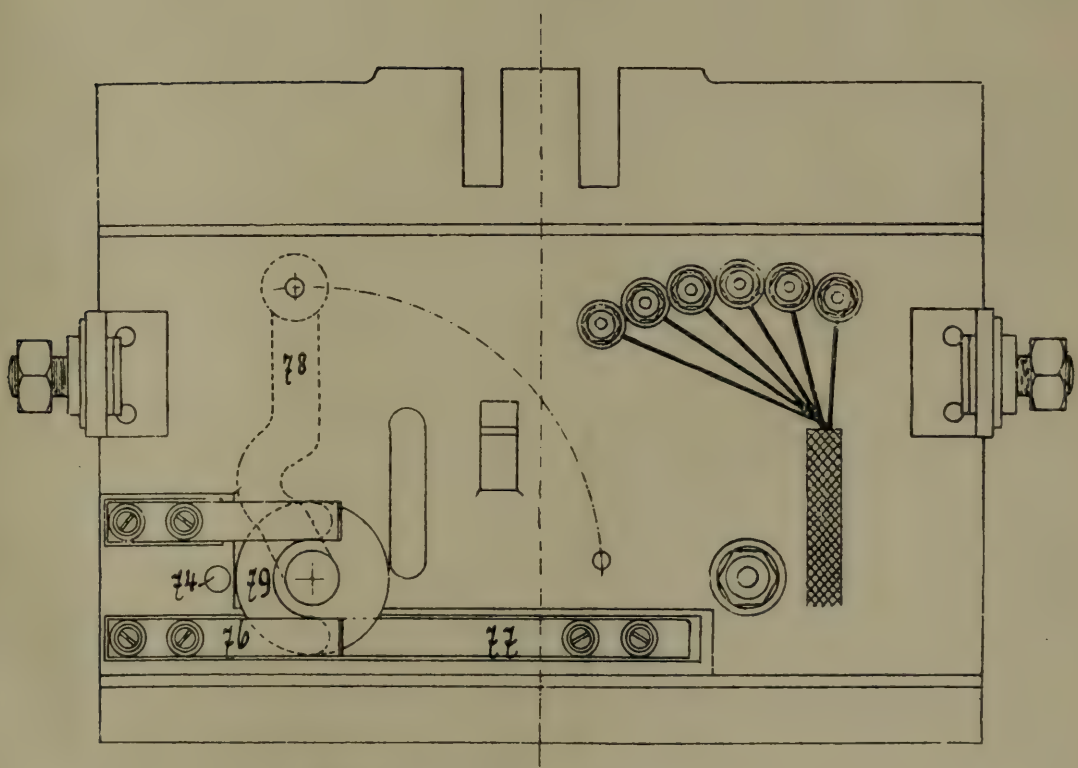




SCHUCKERT HORIZONTAL LAMP FOR SEARCH LIGHT.



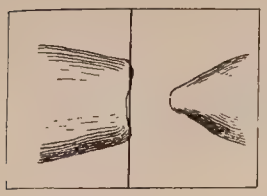
Rear view of casing.

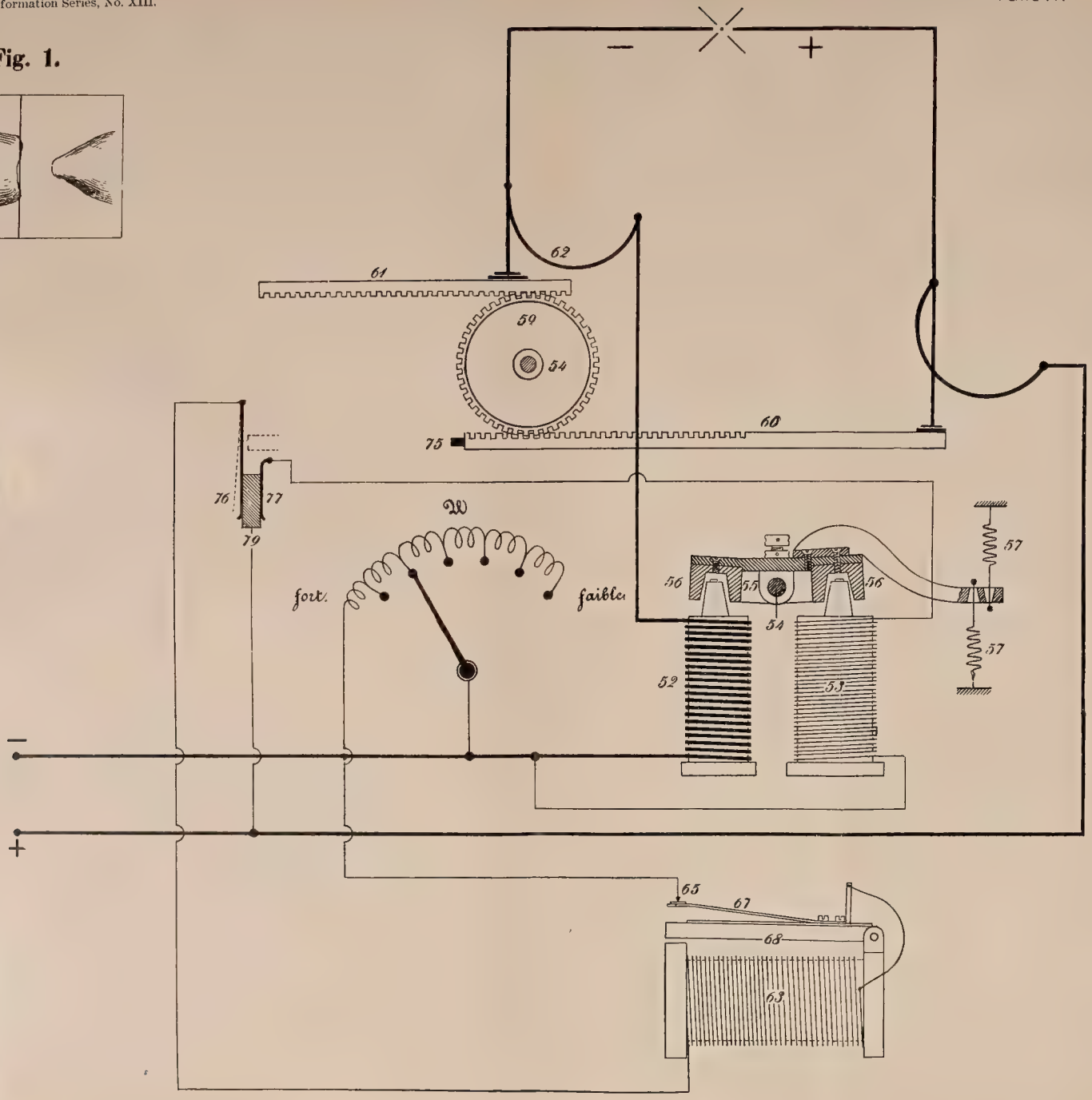


Connections on inside of casing at rear end.

SCHUCKERT HORIZONTAL LAMP.

Fig. 1.





PLAN OF CONNECTIONS. SCHUCKERT HORIZONTAL LAMP FOR SEARCH LIGHT.

In order to prevent the carbons burning away to such an extent as to endanger the carbon-holders, the insulated contact piece 75 is placed in the rack of the positive carbon carrier, and when the latter is at the limit of its motion, presses against the spring 76, breaking the circuit of 63 and preventing further approach of the carbons.

The lamp is operated by hand by moving a lever 75 in the rear of the casing, which releases the terminal 79 from the springs 76 and 77, thus breaking the circuits of both the high-resistance electro-magnets. The series magnet 52 remains in circuit and aids in striking the arc and separating the carbons. The movement of the latter is now controlled by turning the hand wheel 80 by hand, the movement of this wheel being communicated through the endless screw 64 to 58 and 59.

The feeding action of the electro-magnet is 63, is adjusted by means of adjustable resistance in circuit with it, the adjustment being made by a lever on the near end of the casing of the lamp.

A new type of projector is at present under construction for the battle ships. They are intended to be for electrical control, with a new design of motors, and are to be smaller and lighter than those now in service. A horizontal lamp has been devised by the General Electric Company which has given very satisfactory results in tests, the light being clear and steady and much more satisfactory than that given by the present automatic lamp. The mechanism is simple, and admits of use either by hand or automatically.

The French have partially adopted a plan of rigging their search lights out from the side of the ship and operating them by means of electric motors. In the first types the projector was placed on an outrigger, which was rigged out of a port. In later designs the projector is suspended from the outrigger, which sometimes is placed on the battery deck, operating through a port, and at others is rigged as a davit, being secured vertically when not in use. The advantage of having the projectors entirely outside of the ship is that the eyes of the observers and operators are relieved from the glare and from the light reflected from davits, rigging, etc., which is frequently very objectionable. The objections are in the additional complexity involved, the necessity of electrical control, and in the interference with the operation of the battery.

The firm of Sautter et Harlè have supplied over 2,800 Mangin projectors to different countries, and their work is invariably of the highest degree of excellence. The present type of electrically controlled projector made by them is illustrated in figs. ——, taken from Moteurs Electriques à Courant Continu.

The movements of the projector both in training and in elevation are due to one motor M, figs. 15, 16, having one field coil, but two armatures P and P′, the latter operating the training mechanism and the former the elevating. The field of the motor is in shunt to the mains and is always excited when the projector is in operation, while the currents in the two armatures are regulated in strength and in direction by two control boards.

The mechanism is very compact. The training armature P′ has a pinion on its axis which engages in the wheel R′. On the axis of this wheel is an endless screw working in the geared wheel B, and through the pinion C, the large cogwheel C′, which is securely fastened to the base S of the projector. The geared wheels C and B have

their axes in line connected by the clutch coupling A. When it is wished to work the projector by hand, this coupling may be thrown out of gear by the lever E.

The armature P turns the screw T through the intermediary of R and V′. On this screw is the traveler J, connectedto the vertical shaft operating the levers L, L′, L″, the last one being connected to the barrel of the projector. As the screw T rotates in one direction or the other, the traveler J rises or falls, elevating or depressing the projector barrel. As there is a possibility of current being kept on the motor after the projector barrel has reached the limit of its travel, causing the burning out of the motor armature, an automatic safety device is interposed. Attached to the traveller J is a finger F, which plays between two others, G and G′. If J rises so far as to endanger the safety of the motor, F comes in contact with G and moving it slightly operates a switch, which breaks the armature current and prevents any further rise. Current can be sent through the armature P in the opposite direction only. Similarly when J is too low, F comes in contact with G′, breaking the circuit and placing the switch in such a position that the motor can work only to lift J.

The general plan of the connections is shown in fig. 17. There are two movable levers, C and C¹. The former controls the elevation of the projector, moves in a vertical plane, and is placed horizontally to break the current in the elevating armature. The other, C¹, controls the training armature, and is placed vertically when the current is to be broken. Each lever carries contact pieces at its extremities, which connect the semicircles *d* and *e* with the contact pieces *a*, *b*, *c*, *f*, etc. As it is moved from its central position it makes contact with the terminals of the resistance coils R or R¹, and current passes in the corresponding armature. The strength of the current depends on the amount of movement of the lever, the direction of the current being dependent on the direction of the lever's motion. When either lever is released by the hand it is brought by springs into the central position again, the current is broken, and the armature of the motor short circuited, bringing it to rest.

The field E is excited as long as the switch I is on "marche." G represents the dynamo, R_1 the rheostat for reducing the voltage, and D and F the two armatures of the motor. The two switch arms, H and L, work between the terminals K and I, and K¹ and I¹, respectively, these being connected to the movable fingers of the automatic safety apparatus. Thus if J moves upward L will, by the operation of a spring brought into action when horizontal, fly over from J to K¹, and of course no further motion can occur in that direction. If, however, the lever C of the central stand is moved to a position at right angles to that shown in the figure, the direction of the current is reversed and motion of the armature results in the opposite direction.

Momentary movements of the lever to the first contact point cause slight movements of the projector when delicate adjustment is wished.

The subject of internal communications is one of great importance aboard ship, and many electrical installations for this purpose have been made. Most of our ships use the apparatus constructed by the Standard Thermometer Company, of Peabody, Mass., identical in general type with the indicator apparatus made by the same company for use ashore. On shipboard, however, these instruments have not operated satisfactorily. They are constructed on the step-by-step principle, a system which accumulates errors, causing every mistake to give a false indication on the dial. This difficulty is inherent in all apparatus of this type, and is a serious objection to its use on shipboard where vibrations of bulkheads, rusting of springs, or change of E. M. F. is liable to cause a slip in working and a resulting error. The Standard Thermometer Company have recently constructed a rudder telegraph on another system which they believe will remove the objections found against their other instruments.

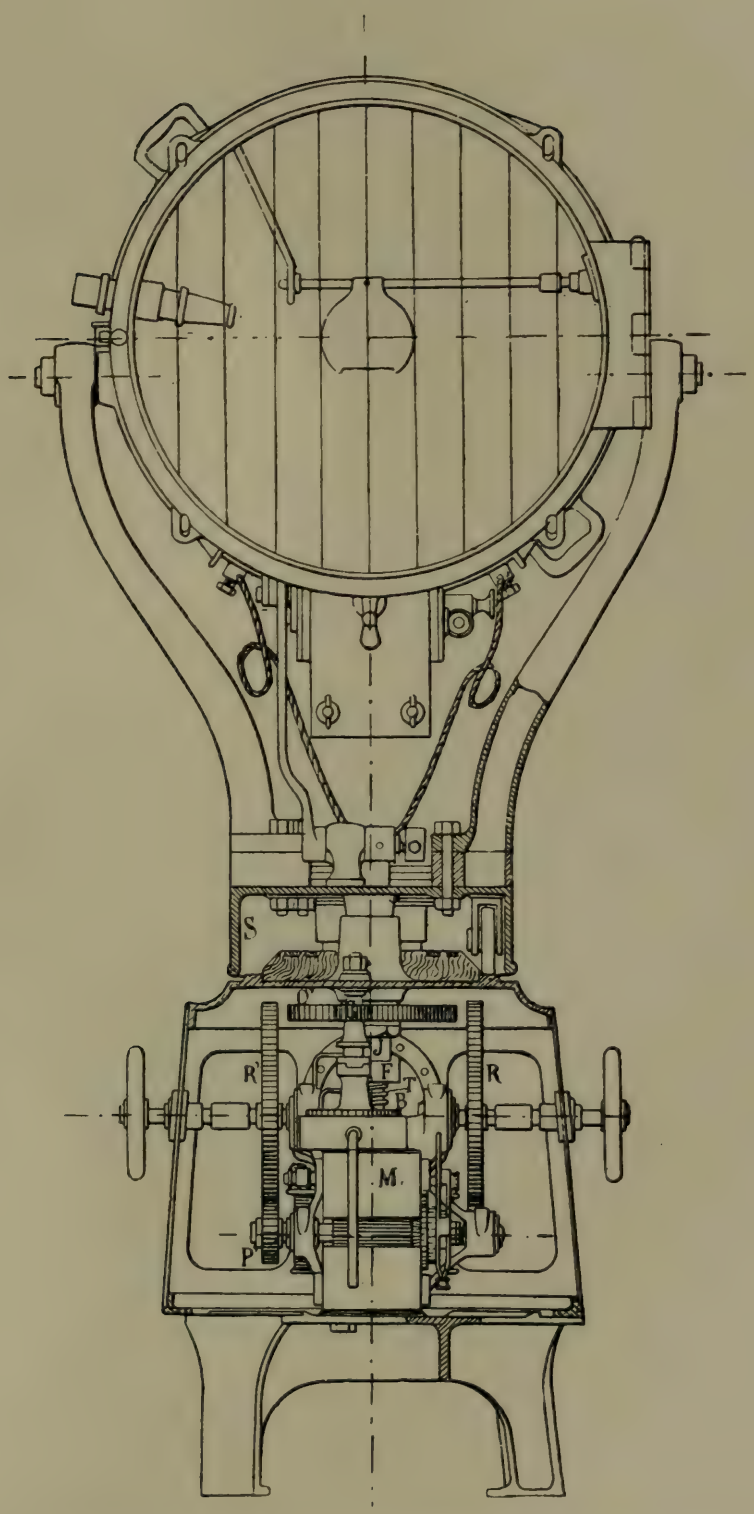


Fig. 15.—ELECTRICALLY CONTROLLED PROJECTOR OF SAUTTER AND HARLÉ.

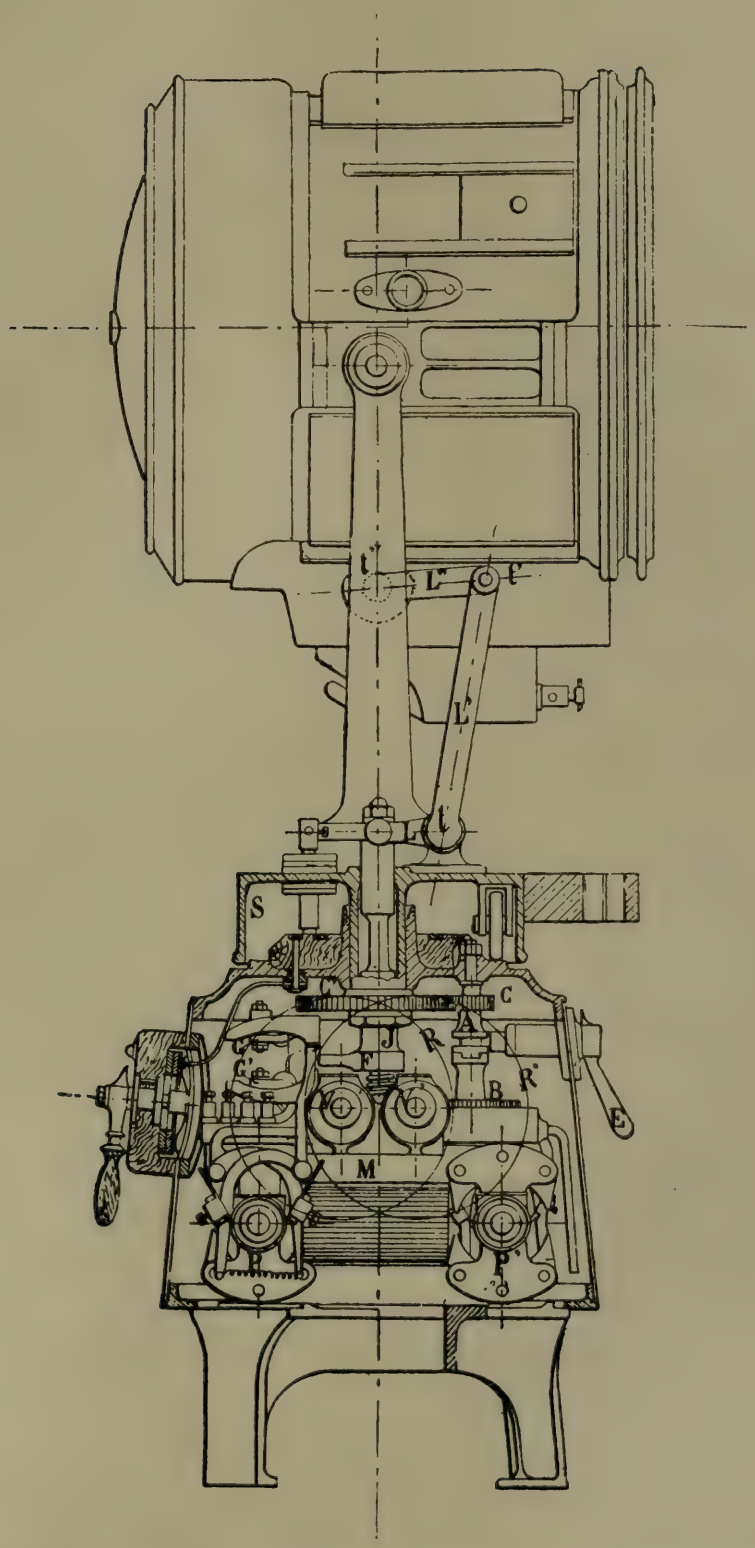


Fig. 16.—ELECTRICALLY CONTROLLED PROJECTOR OF SAUTTER AND HARLÉ.

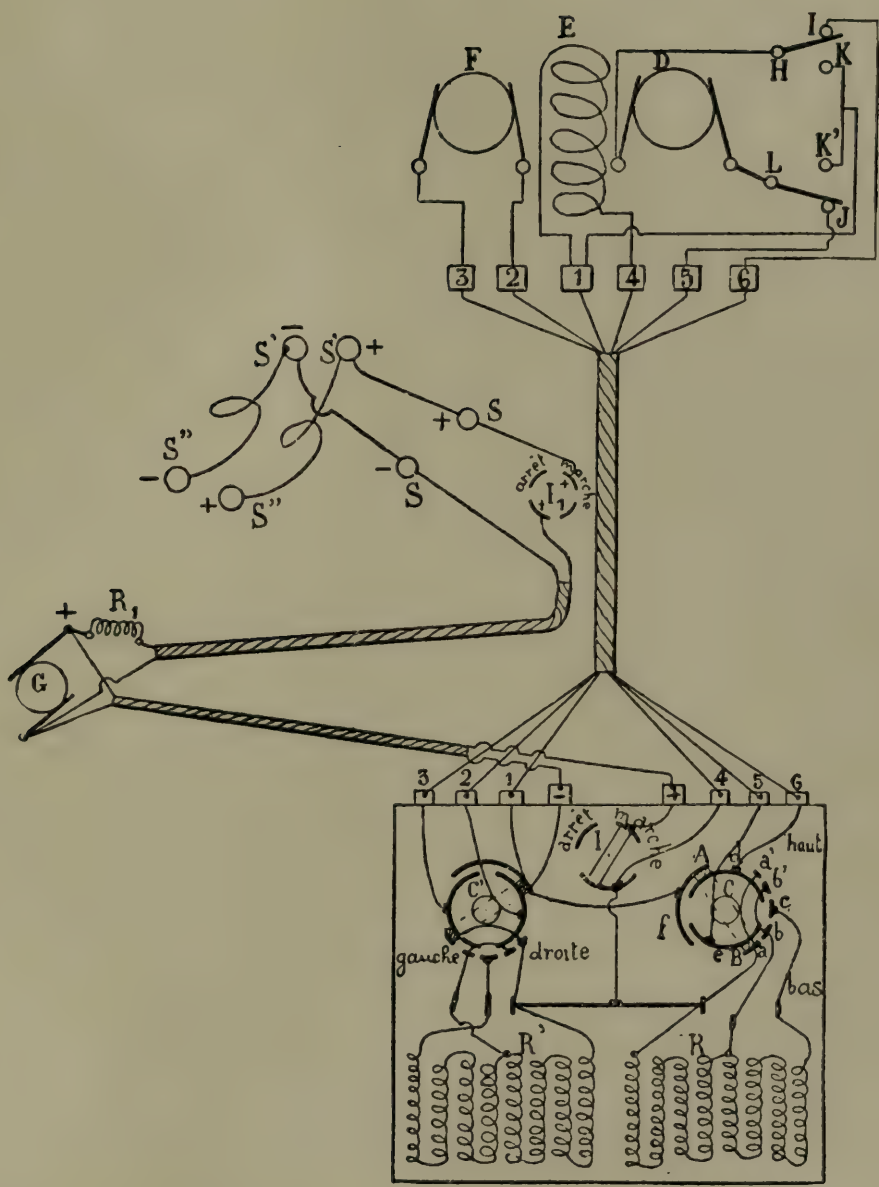


Fig. 17.—CONNECTIONS FOR ELECTRICALLY CONTROLLED PROJECTORS—SAUTTER AND HARLÉ.

The firm of Elliott Brothers, of London, have fitted a large number of ships of the British navy and a few of other services with a complete line of indicator apparatus of the Willis and Spratt patterns. The reports furnished by the manufacturers indicate that this apparatus has given satisfactory results under conditions of active service, and in order to test it thoroughly the Bureau of Equipment has ordered a complete outfit of rudder and engine-room telegraphs and indicators, and engine-speed indicators for the *Maine*. It is to be hoped that the results will be as satisfactory in our service as in the British navy.

In all electrical indicating apparatus a prime necessity is that it should be incapable of giving a wrong signal. It can readily be seen when the indicator is not working, and in that case no reliance would be placed upon it; if, however, it is working and in error, it is worse than useless. While, of course, necessary that it should work under all conditions, it is still a great advantage to have it refuse to work unless in good order. In all apparatus of the step-by-step type this condition is unfulfilled, as the needle moving over the dial will possibly give wrong indications. A difficulty is found on shipboard in the working of transmitters and receivers in parallel, as is called for by the Standard specifications, from the necessity of making a correct adjustment of electro-motive force or resistance in the circuit of each instrument. When the adjustment is once made, a change of electro-motive force in the battery may result in some instruments working while others do not, necessitating a readjustment. This trouble is obviated in the Willis telegraph by a system of switches which allow only one receiver and one transmitter to be in circuit at the same time; but it is then necessary to bring every instrument to its zero before throwing in or out of circuit.

The experiment has been made aboard the *Miantonomoh* suggested by Capt. Sicard, of using a number of incandescent lights with the helm indicator. A contact piece connected with the tiller moves over an arc divided into a number of segments, each segment being in connection with a small incandescent lamp in the pilot house, and the exact position of the helm is at once made evident by the lamp corresponding to that position burning, while the others do not. A similar apparatus in which the lamps are arranged in a circle behind a glass dial has been installed on board the *Cincinnati*.

An apparatus for indicating the speed of the engines, on deck or in the pilot house, is very desirable. The only exact method is to have each revolution indicated electrically and then to count the number of these indications in a given time. The attempt has been made to construct integrating instruments which will show the speed at a single glance, but, as these all involve some auxiliary machinery, an additional error is involved which is objectionable, the indicating apparatus on deck frequently giving results differing widely from those of the engine-room counter. It would seem advisable to adopt some electrical

arrangement to this counter, arranging it so that it could be thrown in or out as desired, and repeating the indications of the counter in the pilot house. The number made in 15 seconds, which time could easily be spared for observations, would indicate the speed of the engine with exactness.

The French have adopted electric motors more extensively than any other navy. In most of the recent ships the ammunition hoists are operated by electricity, with alternative hand control. In several, among which may be mentioned the *Jaureguiberry*, the gun turrets are revolved by electricity. Ventilation by means of electric motors and fans is common. The steering engine is controlled by electricity in the *Jaureguiberry*, and electric capstans are designed for some of the later ships.

The Chilean cruiser *Capitan Prat*, designed and built by the Société des Forges et Chantiers de la Méditerranée, has probably the most extensive electric plant of any man-of-war as yet built. The ship is lighted throughout by incandescent lights, is fitted with search lights, operates all its guns and ammunition hoists by electric motors, and has an elaborate system of internal electrical communications. The operation of gun turrets by electric motors has already passed the stage of feasibility, and become a question of mechanical detail only. The following particulars of the installation aboard the *Capitan Prat* is taken from Moteurs Electriques à Courant Continu, by H. Leblond, and will be found of interest:

The plant for operating the turrets is separate from that for the ordinary lighting of the ship, and consists of two units, one for each turret. Each unit consists of a horizontal engine and two direct coupled 6-pole compound dynamos, each wound for 70 volts and 500 amperes, at a speed of 300 revolutions. The dynamos are ordinarily connected in series, the shunt fields being also in series, so that each unit becomes practically a single dynamo, with an output of 500 amperes at 140 volts. Three wires are taken to the switch board, and connections made so that the field coils of the motors have only 70 volts at their terminals, while the armatures receive the full 140. In case of accident to one of the units, both turrets can be worked by the other, the connections being changed so as to put one dynamo on each, everything operating at 70 volts.

The training motors are of the Manchester type, compound wound. Two are used for each turret, placed on opposite sides of the turret, and working it by means of the gearing and chains shown in fig. 18. The ends of the chains are secured to powerful springs to afford a little elasticity of movement. In case of accident to the electrical system, hand brakes may be shipped on the armature axes, and, with the field circuits broken, the turrets may be moved by hand.

The motors are controlled by a central stand in the turret, shown in the upper part of fig. 20. This acts through a system of relays to send currents of desired strength in either direction through the armatures of the motors. One of these relays is shown in fig. 19. When the current from the central stand is passed through the electro-magnet G, the resulting movement of the armature C brings the insulated spring plates F down on the contact pieces D and E, establishing communication between them, and allowing current to pass to the motors. In order to prevent sparking when the current in G is broken, a spring lever (M N) is attached to F, keep-

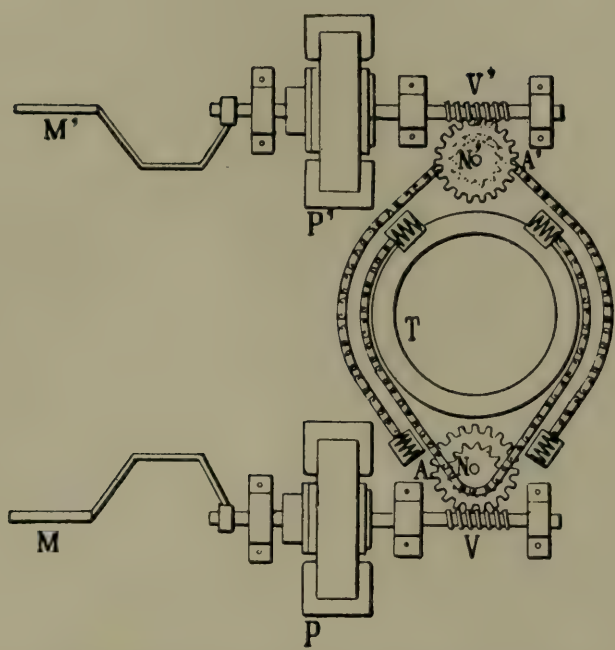


Fig. 18.—SYSTEM OF MOUNTING ELECTRIC MOTORS FOR ROTATING THE TURRETS OF THE CHILIAN CRUISER CAPITAN PRAT.

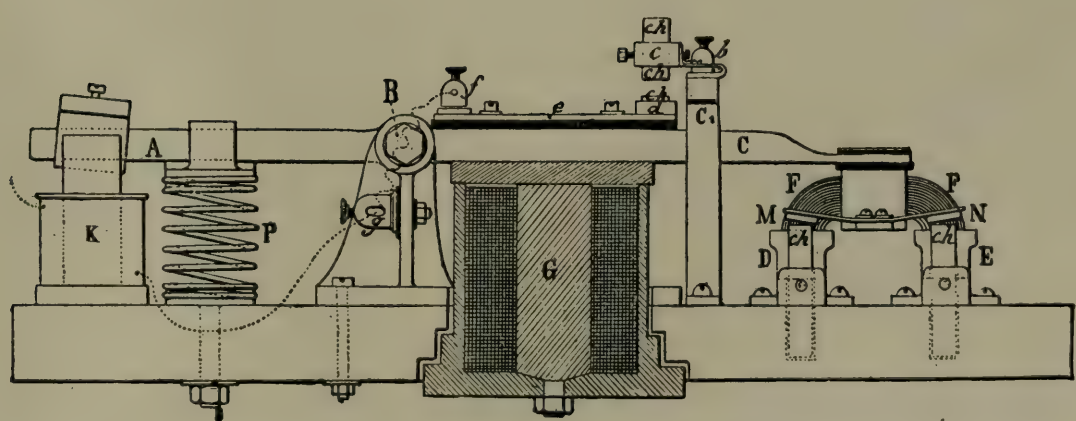


Fig. 19.—RELAY FOR CONTROLLING WORKING OF ELECTRIC MOTORS FOR TRAINING TURRETS ABOARD THE CAPITAN PRAT.

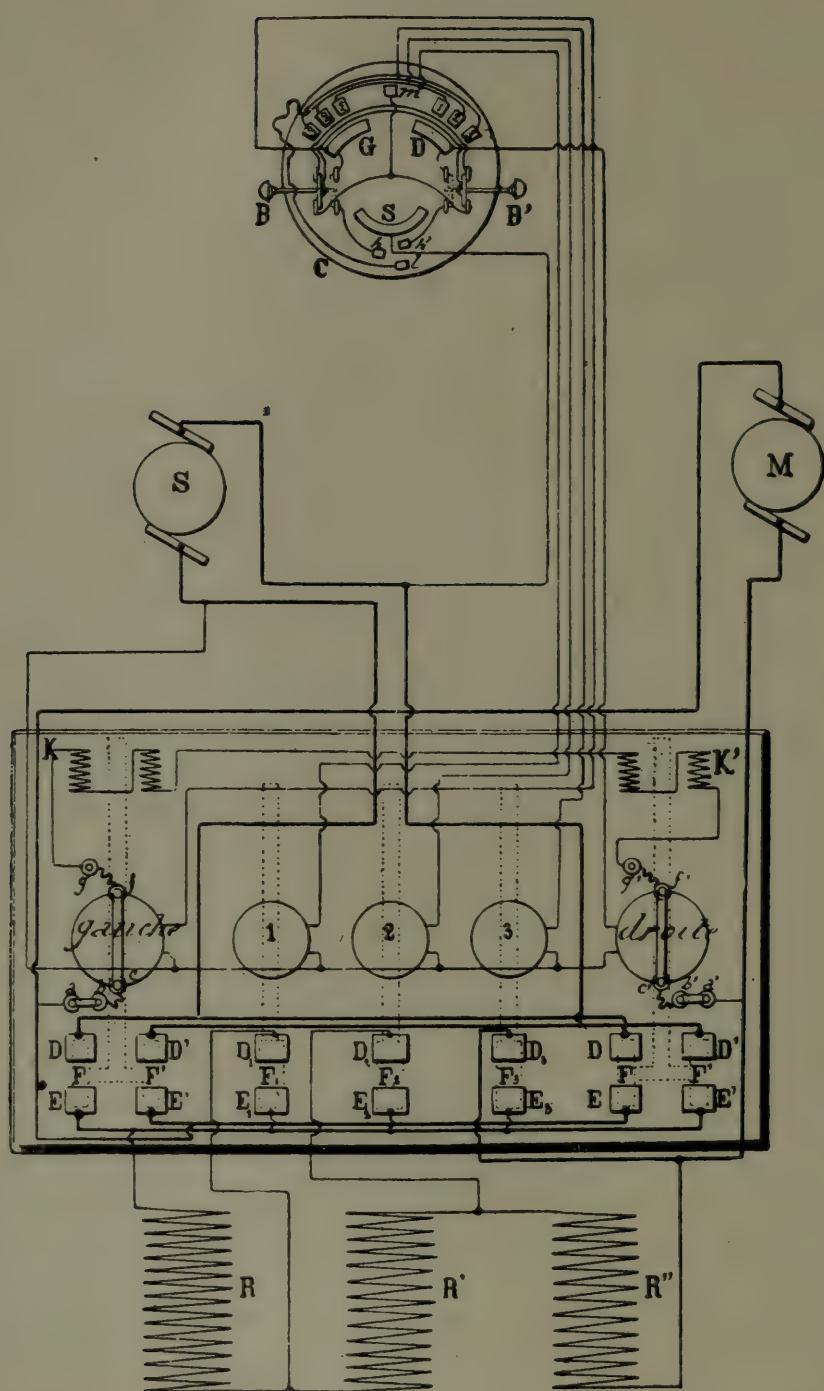


Fig. 20.—CONNECTIONS BETWEEN CONTROL STANDS, RELAYS, AND TURRET TRAINING MOTORS OF THE CAPITAN PRAT.

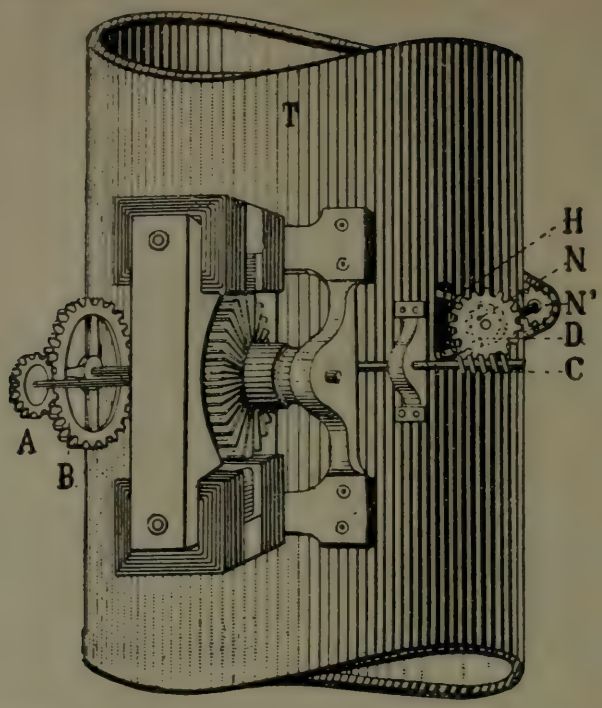


Fig. 21.—AMMUNITION HOIST MOTOR FOR 24cm. GUNS OF THE CAPITAN PRAT.

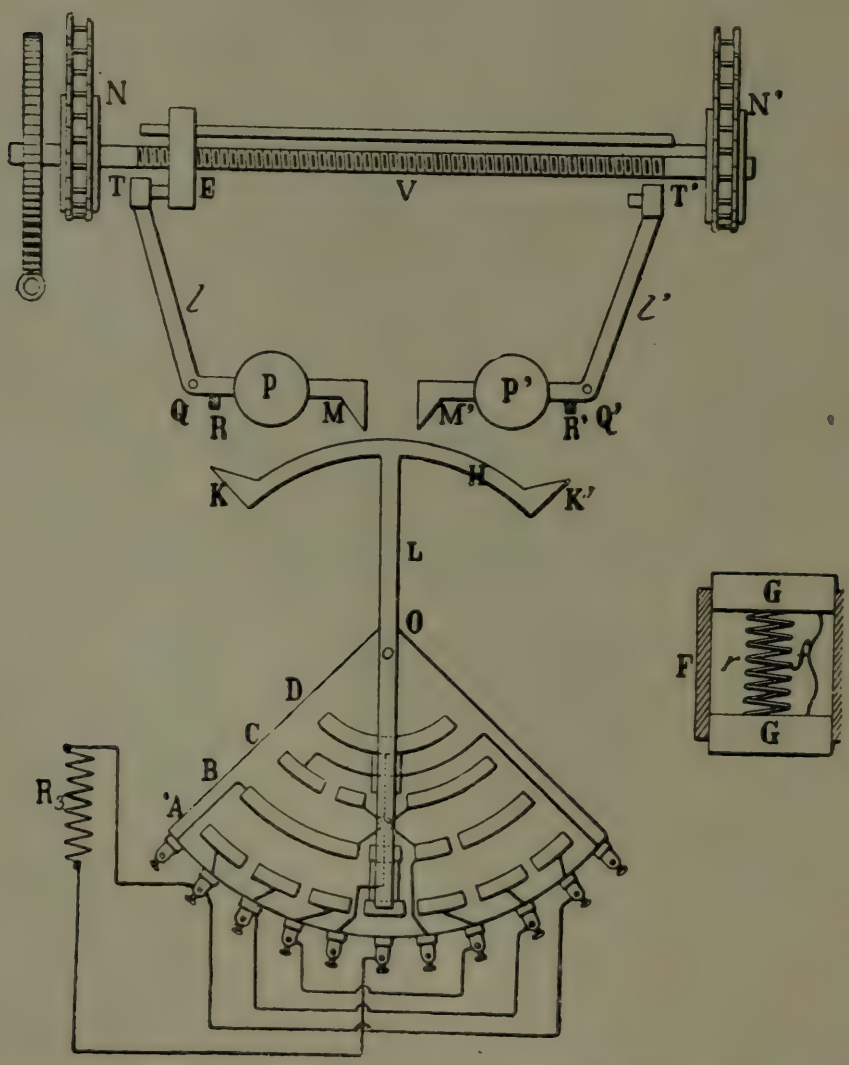


Fig 22.—CONTROL STAND AND AUTOMATIC INTERRUPTER FOR AMMUNITION HOIST MOTORS, CAPITAN PRAT.

ing in contact two pieces of carbon attached to D and E up to a certain point, when they fly off rapidly, making a quick break in the motor current.

On top of the armature C is a carbon contact which touches another stationary one, when the armature rises from the current in G being broken. The contact between these two pieces of carbon sends a current from the motor armature through the electro-magnet K, attracting the lever A, and assisting in making a quick break at M and N, while short-circuiting the armature in itself and bringing it to rest.

The central apparatus in shown in plan in fig. 20. The plate S of the turret instrument is connected direct to one side of the dynamo circuit, and the current is thrown either to D or G by moving a contact lever not shown in the figure. There are three contact points, 1, 2, and 3, on each side connected to the rheostat coils R, R′, R″, admitting of four strengths of current and corresponding speeds. On each side of the turret instrument is a push button B and B′. These buttons are connected to the contact segment 2, and when pushed in, send a current to the motors through two coils of the rheostat. They are intended for making slight changes of train only.

If the lever of the turret instrument is placed on the right-hand segment, marked 1, current passes from the dynamo through the electro-magnets of the relays *droite* and 1. The movement of the armatures closes the switches F_1 F′, and F, making contact between D′ and E′, D_1 and E_1, and D and E. The current then passes from the dynamo S, through D E, to the motors M, the resistance coils R′ and R″, the contacts D_1 and E_1, and D′, E′, back to the generator. As there are two resistance coils in circuit, the resulting movement of the motors is slow and causing the turret to move to the right. If the contact lever moves to segment 2, the resistance coil R′ is cut out, and the motion is more rapid.

If the contact lever is brought back to its central position the main coils of the electro-magnets *droite* and *gauche* are cut out, but the coils K and K′ are in series with each other, forming a shunt to the motor armatures. The momentary current, due to the short-circuiting of the motors, is so great as to bring the motors to a dead stop.

In order to prevent accident to the motors, automatic switches are placed in circuit, arranged to open the circuit before the turret reaches the limit of its movement in either direction.

The ammunition hoists of each turret is operated by a small electric motor, bolted on the outside of the turret spindle, as shown in fig. 21. This motor works at 500 revolutions, and by means of the gearing shown in the figure, works the endless chains H of the hoist. The motor is operated from a central stand (fig. 22) near it. This consists of a board in the shape of a sector of a circle, having on its face four concentric arcs of contact pieces. Movements of the lever L to right or left from the central position determines the rotation of the motor in one direction or the other, the rotation being more rapid from the cutting out of resistance as the lever approaches the end of the arc. In the central position the motor armature is short-circuited through an auxiliary resistance and brought to rest.

To prevent the operation of the motor when the hoist is at either top or bottom of its tube an automatic safety device is used. A traveler, E, moves along the endless screw V, forming the axis of the pulleys N and N. When the lever L is put over in either direction, one of the toes, K or K^1, engages in M or M^1, and remains there until the movement of the traveler E brings it against T or T, and by means of the levers 1 or 1^1 trips the contact, allowing the lever L to be brought back to the central position by weights or springs, while an attachment to the lever 1 or 1^1, as the case may be, prevents the lever L being put over again in the same direction.

Fig. 23 shows the electrical connections from the switch board to the motors at each turret. The lettering is as follows:

I M C.—Armature. E M C.—Field. C M C.—Central stand. R_1.—Adjustable armature resistance. R_2.—Adjustable field resistance. R_3.—Auxiliary resistance for short-circuiting armature.	Ammunition, hoist motors.
I P L, I^1 P L.—Armatures. E P L, E^1 P L.—Fields. C^1 P L.—Turret central stand. C P L.—Relays. R.—Adjustable armature resistance. $I_1 I^1$.—Automatic safety switches.	Motors for rotating turrets.

C C.—Safety cut outs.
T.—Turret spindle.
P C.—Protective deck.
A.—Switch board with connections to dynamos.
Fig. 24 shows the arrangement of the plant in place.

The turrets have a rotation of 270 degrees of arc, and the time required is stated as 1 minute 27 seconds, 1 minute 17 seconds—1 minute 12 seconds, or 1 minute 4 seconds, according to the resistance in circuit. The ammunition hoists raise a total weight of 800 kilograms, about 10 meters, in fifty-seven seconds. The training moters require 25 amperes in the field and 45 in the armature, the corresponding currents for the armature hoists being 15 and 40 amperes.

The ordinary electric lighting of the ship is carried on by two Manchester dynamos, each yielding 250 amperes at 70 volts.

Apparatus has been fitted aboard the French cruisers *Latouche, Tréville,* and *Pothoau* for revolving the gun turrets and hoisting ammunition by electric motors. The installation was made by the Société des Forges et Chantiers de la Méditerranée.

The turret spindle is made of large diameter, and in the shape of an inverted frustrum of a cone. The motor for revolving the turret is situated underneath the protective deck, and operates on a gearing extending around the conical support of the turret, the motor speed being diminished by an endless screw in the armature shaft, operating proper reducing gear. The shaft is prolonged outside the ordinary bearing to allow of a hand break being fitted, to furnish hand control in case of accident to the electrical system. The motor is of the Manchester type, and is operated from a control board in the turret.

The ammunition hoist is inside the turret support, and consists of an endless chain carrying shelves on which the charges rest. They are brought up to the left of the gun and deposited on a hinged platform, which, on being swung around 180 degrees brings the charge fair for the breech of the gun. The electric motor is secured to the outside of the revolving turret support, turning with it, and geared to a vertical shaft which by bevel gear operates the lower pulley of the ammunition hoist. In case of accident to the electric motor or connections, the hoist can be operated by hand by means of a crank shipping on the shaft of the lever pulley.

An apparatus known as an "audible directiere indicator," has been fitted to a number of mechanical engine-room telegraphs in the British mercantile marine. It consists of an electrical attachment to the ordinary telegraph, so arranged that when an order has been signaled from the bridge to the engine-room, the electric bells ring in both places until the engine actually commences to work as directed. Both bells will ring whenever the operation of the engine is different from that called for by the position of the pointer of the deck transmitter of the telegraph.

Capt. J. R. Crampton, R. A., and Mr. W. O. Smith, of firm of Elliott Bros., have

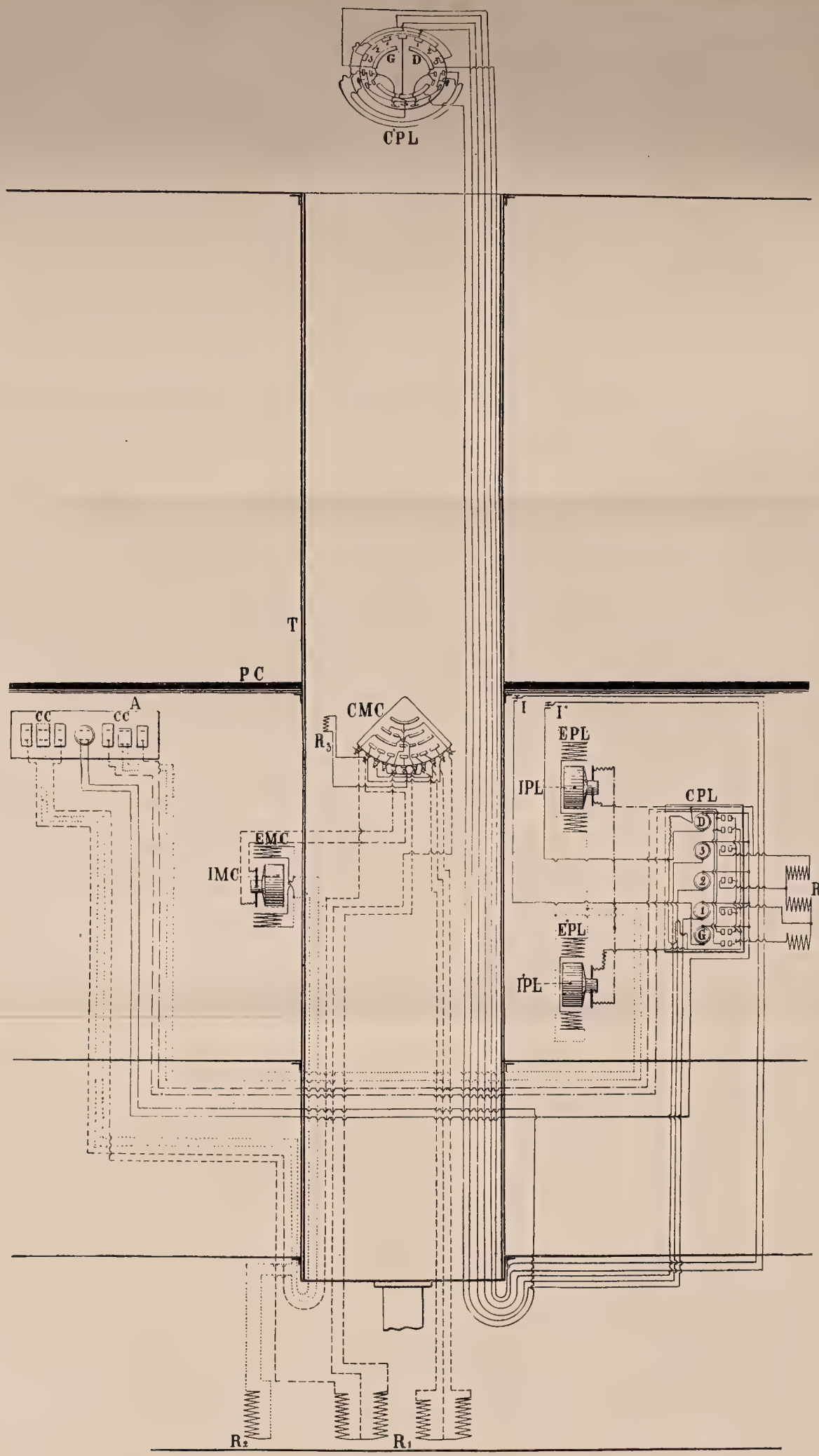


Fig. 23 — PLAN OF CONNECTIONS FOR THE TRAINING, AND AMMUNITION-HOIST MOTORS OF ONE TURRET OF THE CAPITAN PRAT

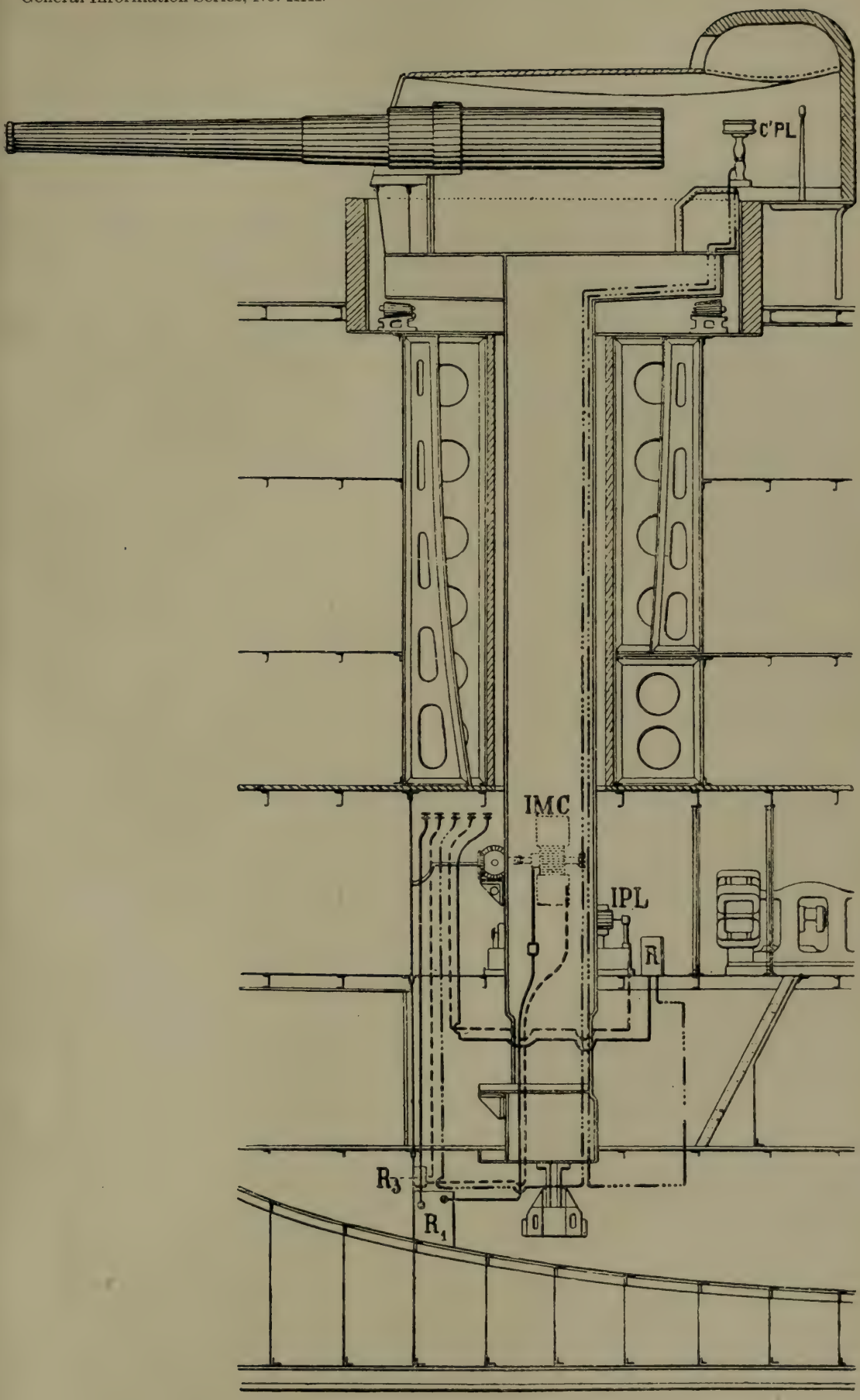


Fig. 24.—ARRANGEMENT OF TURRET GUN MACHINERY OF THE CAPITAN PRAT.

invented a range finder. Telescopes are located at any desired number of observing stations, and at concerted simultaneous signals are directed to the object whose distance is desired, and beams of light, showing accurately the angle of each telescope with a meridian or base line, are made on a chart at a central station. The intersection of these beams shows the position of the object and may be readily measured.

The Ongley Electric Company of Hoboken are commencing the manufacture of a line of instruments which bid fair to be of interest to the Navy. They have installed aboard the *New York* an electrical system of signaling either by whistle or by the flash of the searchlight; the signals being made by an ordinary Morse key. The general system is the control of a valve or a lever as may be desired by an electro-magnet which is energized by the current passing through the key when closed. The company have designed an apparatus constructed under this general plan for controlling the stop valve and links of the main engines of the ship from the bridge, rendering it possible for the engine to be stopped or reversed in an emergency by direct action from deck without the possible delay involved in signaling the engine-room.

VI.

MARINE BOILERS

By Passed Assistant Engineer ROBERT S. GRIFFIN, U. S. Navy.

As in the merchant service, so in the navies of all countries, the general type of boiler in use for years has been the cylindrical return-fire tubular, or Scotch boiler, either single or double-ended. Of late, however, water tubular boilers have come to the front for naval purposes, and now nearly all the Great Powers are either using or experimenting with some type of this boiler.

As is well known, the boilers of the Martin type, used in our service during the war and after it, were very satisfactory for the pressures then carried, but were objectionable on account of the unavoidable salting up of the tubes. France was the next country to try water-tube boilers in her navy, the Belleville having been in use there for the past fifteen years, and the same type was subsequently used in the *Minin* of the Russian navy. In our own Navy the *Monterey*, with Ward "coil" boilers, is probably the first vessel of any navy, other than torpedo boats, to be fitted with bent-pipe boilers, and thus far they have worked satisfactorily and given little or no trouble.

The next most important adaptation of them in our Navy is for gunboat *No. 7*, building by the Newport News Shipbuilding and Dry Dock Company. She is to have four water-tube boilers of 1,600 I. H. P., besides two cylindrical boilers; the latter are for use in long-distance steaming at an economical rate of speed, and are of such design that they can be readily scaled, provision being made in their design for feeding them with salt water in case of necessity, so as to keep up a supply of fresh water for the tubulous boilers. There are, besides, a liberal evaporating plant, and fresh-water tanks, so that the tubulous boilers may be used in ordinary steaming if necessary or desirable. The type of boiler that will be fitted in this vessel has not yet been determined upon, but will probably be the Yarrow. Next in importance to this come the four second-class torpedo boats for the *Maine* and *Texas*, each of which will have a Mosher boiler of about 250 I. H. P.

In the new design of machinery for the *Chicago* it is probable that more than one-half the power will be in water-tube boilers, sufficient

power in cylindrical fire tubular boilers being provided for 10 to 12 knots cruising speed.

When we come to mercantile work in this country, the number of vessels using water-tube boilers is very large, as is also the number of types. The greatest example of their use is in the steamer *Northwest* on the Lakes, intended to run from Buffalo to Port Huron. She has 28 Belleville boilers, which are designed to furnish steam to two quadruple expansion engines for 7,000 I. H. P. For a vessel engaged in such service—in fresh water—the conditions are, of course, somewhat ideal for the successful use of tubulous boilers.

Last year the British Government determined to try a water-tube boiler, and so entered into a contract for eight Belleville boilers for the *Sharpshooter*, whose trials with locomotive boilers had hitherto been one succession of failures. The trials of the *Sharpshooter* with these boilers are recorded further on, but it may be here mentioned that while the Belleville company did not make any guaranty as to horse power, the boilers fulfilled the requirements as to rate of combustion and evaporation; and that although the I. H. P. required in the original design of the *Sharpshooter* and class, 4,500, was never realized, vessels of the same type fitted with locomotive boilers have developed upwards of 3,500 I. H. P., a few hundred more than the *Sharpshooter* did on her last trial. The British Government is, however, so well pleased with this type of boiler that the *Powerful* and *Terrible*, each of 25,000 I. H. P., are to have them. Another torpedo vessel, the *Spanker*, will have Du Temple boilers; the *Speedy* has Thornycroft of 4,675 I. H. P., and the *Hornet* Yarrow boilers of 4,300 I. H. P., while there are about 40 vessels now building similar to the *Hornet*, nearly all of which will have water-tube boilers.

In France nearly every new vessel building is being supplied with some type of water-tube boiler, the preference apparently being for the Belleville and the Lagrafel D'Allest, though many other types are being tried. In the larger vessels it is invariably a straight-tube boiler, while in torpedo boats the bent tubes seem to be in the majority.

In Germany little has been done in this direction as yet, though Mr. Thornycroft stated at the spring meeting of the Institution of Naval Architects that his firm had been given a contract to put boilers of his *Speedy* type in the *Siegfried*. Nearly all of the German torpedo boats are by Schichau, and are therefore fitted with the locomotive boiler. In fact, Herr Schichau is about the only torpedo-boat builder of any note who has not either designed a water-tube boiler of his own or tried one of another's make.

Russia is also trying the Belleville in a ship of about 15,000 I. H. P., after having tried it in one of 2,000, and has recently entered into contract with Yarrow & Co. for a torpedo-boat destroyer which will be fitted with boilers similar to the *Hornet's*.

Before passing to a description of some of the types of water-tube boilers, it will be well to show what has led up to the sudden abandonment of the cylindrical boiler in Great Britain for vessels of high power. A glance at the accompanying table will show that attempts have been made to get an I. H. P. from less than 1.5 square feet of heating surface, and the result has been, as might have been expected, that the power was not obtained, and the boilers practically ruined before being turned over to the Government. Then, the type which seems to have commended itself, on account of economy in space, was the common combustion chamber boiler. In consequence of the trouble with boilers due to leaky tubes, and the repeated failures of vessels on trial, and especially of those with boilers of the last-named type, a commission composed of engineer officers of the Navy and engineering representatives of the Board of Trade and Lloyd's was appointed to inquire into the subject and to recommend such alterations and modifications in design as might obviate the difficulties hitherto encountered, and to submit such suggestions as might result in the production of a design which would insure the attainment of the stipulated power without permanent injury to the boilers. The result of their deliberations is the practical abandonment of the common combustion-chamber boiler, an increase in heating surface per I. H. P., and the experimental trials of the Belleville and Du Temple boilers in the *Sharpshooter* and *Spanker*, and of the Thornycroft in the *Speedy*.

Boilers of—	Steam pressure.	Number.	Diameter.		Length.		Grate surface.	Heating surface.	I. H. P.		Heating surface per I. H. P.	
									Design.	Trial.	Design.	Trial.
			Ft.	*In.*	*Ft.*	*In.*	*Sq. ft.*	*Sq. ft.*			*Sq. ft.*	*Sq. ft.*
Vulcan	150	4 1	14 12	0 5	17 9	0 4	655	19,000	12,000	12,032	1.583	1.579
Blake	155	6 1	15 10	2 0	18 9	0 0	863	26,963	20,000	14,525	1.348	1.856
Edgar	155	4	16	0	18	0	812	23,680	12,000	12,463	1.973	1.900
Medea	155	4	12	0	.....		.....	15,882	9,000	9,435	1.765	1.683
Sappho	155	3 2	13 13	0 0	18 9	6 6	590	15,770	9,000	9,280	1.752	1.699
Royal Sovereign class	155	8	15	2	9	4	700	19,560	13,000	11,500	1.505	1.701
Barham	150	6	[1]6	5	15	8	252	8,200	6,000	4,537	1.367	1.807
Hebe	155	4	[1]7	6	15	6	163	6,163	3,500	3,566	1.761	1.728

[1] Locomotive type.

Turning to the table, the *Vulcan* was first tried in the early part of 1891, but the best that could be got out of her was a little more than 8,000 I. H. P. Attempts to go beyond this invariably resulted in leaky tubes or in priming, or both. The smoke pipes were lengthened 20 feet in the hope of helping matters, tubes removed to increase circulation, grates shortened, and many other devices tried, but none of them

accomplished the desired results. Finally, just as the removal of the common combustion chamber boilers was determined upon, the "Admiralty ferrule" made its appearance, and its success in pulling the *Thunderer* through her trials was so marked that the tubes of the *Vulcan's* boilers were similarly treated, with the result that, two years after her first trial, she was successful in making a forced draft trial under a pressure of 1.8 inches of water, and developed 12,032 I. H. P., 32 more than the contract called for.

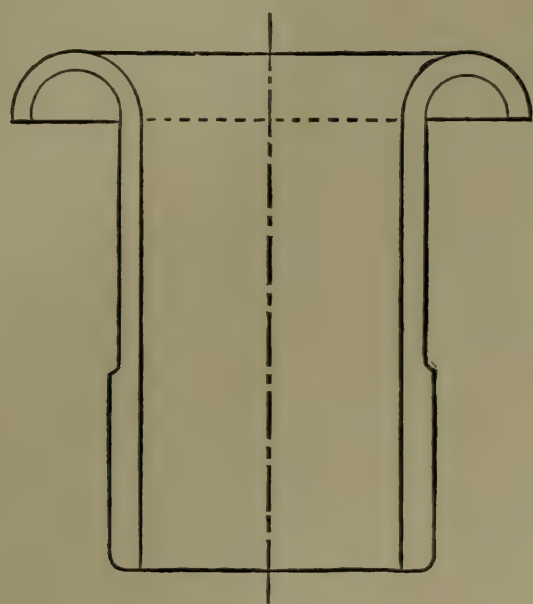
In the case of the *Barham*, the attempt was made to get 6,000 I. H. P. from 8,200 square feet of heating surface and about 250 of grate, in boilers of the wet-bottom, locomotive type, but the attempts to run them at anything much beyond one-half this power resulted in so much leakage around the tube ends as to prevent further attempts in that direction. After repeated failures the smoke pipes were lengthened, and finally the tubes ferruled, and as thus doctored the average I. H. P. for three hours was 4,537, with something more than 2 inches air pressure, beyond which it was not deemed safe to force the boilers. The failure to reach the designed power can not be charged to the type of boiler, but to the attempt to get the impossible. The boilers are six in number, with rectangular fire boxes, grates 7 feet long, tubes 5 feet 6 inches long and staggered, the barrel being almost completely filled with them, leaving little space for water and an inadequate amount for its circulation. Boilers of the same type and design had previously been supplied by the same firm for the Italian torpedo cruiser *Tripoli*, and were singularly unsatisfactory, and it is not at all surprising that better results were not obtained in the *Barham*. After ferruling the tubes the I. H. P. for eight hours was 3,589, and for three hours, 4,537. The final result on the forced-draught trial was practically the same per square foot of heating surface as had previously been obtained from the boilers of the *Tripoli*.

The boilers of the *Blake* were designed for 20,000 I. H. P., but it was thought inadvisable, on account of leaky tubes, to push them beyond 14,500, which she made with one-half inch air pressure. In the *Royal Sovereign*, the forced-draft trial was successful, in that 13,000 I. H. P. was obtained, but the boiler tubes suffered so much that the requirement for all the other vessels of the class was reduced to 11,000 I. H. P. The average for all these vessels was about 11,500, and the boilers passed through their trials without any trouble.

The increase in heating surface per I. H. P. of the design of the *Edgar* over that for the *Vulcan* and *Blake* is a good indication of the absolute abandonment of the old trial-trip boiler with common combustion chamber for the more rational one with separate combustion chamber at each end, either for each furnace or pair of furnaces. The same may be said of the step from the *Medea* to the *Sappho* and from the *Barham* to the *Hebe*.

The Admiralty ferrule referred to is shown in the cut. While it has been eminently successful in helping boilers with leaky tubes through their trials, it is not altogether satisfactory, especially in boilers of the "gunboat" or "locomotive" type, where the tubes are in prolongation of the furnace, and a good idea of the trouble may be had from the following account of one of the trials of the *Hebe*, which is taken from Engineering:

Perhaps the most instructive part of this latter trial is the great additional air pressure for draft required to give another 400 I. H. P. On the official trial, the air pressure was but 2 inches, but on the latter trial, no less than a mean of 3.7 inches was required. The reason is instructive. The tubes of the *Hebe's* boilers are fitted with the Admiralty ferrule. This is a device in which the joint of the tube end with the tube plate is protected by a trumpet mouth, which projects out of the tube and turns back on the plate. As there is an air space between the



tube plate and the turned over end of the ferrule, the latter naturally must get red hot, at any rate, when the boiler is forced to any extent. However this may be, there is no doubt that ferrules of this type conduce to that very unpleasant boiler disease known as "bird's nesting." A "bird's nest," it may be stated for the benefit of those who have not had experience in this direction, consists of a built-up obstruction of small particles of coke or coal. The first thing that happens is that a ring of these particles forms round the crown of the trumpet-mouthed ferrule. This annulus gradually grows inwards across until, in extreme cases, the ferrule mouth becomes entirely closed by a disk of coke-like substance. The mass does not grow up inside the tube, but simply extends across it, forming not a lining, but a lid. In the case of the *Hebe*, after her extra forced-draft trial, in one boiler 10 per cent. of her tubes were, we believe, practically entirely closed. The bird's nest is of so firm a texture that it may be removed bodily, and the various stages of formation are extremely interesting. Judging from examples of bird's nests taken from the *Hebe*, we doubt very much if she could have continued running at the power she did for much longer. That, however, is a matter of opinion, but the boilers were working with 6 inches air pressure at the finish. Of course bird's nesting is no new thing, it having been a matter with which torpedo-boat builders have long been acquainted. The formation of the foundation ring of the nest in bell-mouthed ferruled boilers,

is generally attributed to the fact that the ferrule gets red hot, and it is a curious speculation how near the tube plates and tube ends of torpedo boats' boilers—on which bird's nests have formed—may have arrived to that state. Doubtless a tube-plate can not get red hot when one side of it is in contact with water, but the question is, actually, how near is the water?

In the French navy, boilers both of the cylindrical return tubular and locomotive types have given almost as much trouble as they have in England, and doubtless from the same cause of insufficient boiler power. It is doubtful, however, if this is the trouble with the boilers of the triple-screw cruiser *Dupuy de Lôme*, which began her trials about two years ago. On her last effort, some months since, the corrugated furnaces collapsed. Here the trouble seems to be in the size of the furnaces, 51 inches. New furnaces are being put in, but it will probably be several months before the ship will be again ready for trial.

In our own Navy, it is a pleasure to record the fact that the boilers have never given trouble from leakage on trial, bearing testimony to the judgment in design, in allowing about 2 square feet of heating surface per I. H. P. with forced draft, and to the excellence of workmanship on the part of the builders.

In what follows will be given such data as are available on the design and the performances of water-tube boilers which have been successfully used, or whose use is contemplated in vessels of considerable size or power, beginning with the types used in this country, and following with those used abroad.

THE WARD BOILER.

The boiler shown in fig. 1 is the one fitted on board the revenue cutter *Hudson*. It is similar in all respects to the boilers of the *Monterey*, and is the general type of Ward boiler hitherto built for large power. The cylindrical coils are connected to cast-steel vertical manifolds by nipples having right and left hand threads, and the vertical manifolds to the lower horizontal, or water manifolds by short nipples screwed into the vertical manifolds, and lipped and secured in stuffing boxes in the horizontal manifolds by glands made in halves, the flanges dovetailed together. The upper horizontal, or steam manifold, which connects with the upper part of the central drum, is connected in a similar manner by stuffing box glands to the vertical manifolds. The packing material for these stuffing boxes is asbestos.

The central drum is protected from the heat of the furnace by fire brick.

The following particulars of the boiler of the *Hudson*, and of those of the *Monterey*, are from the Journal of the American Society of Naval Engineers:

Hudson.—Particulars of Ward boiler.

Number of tubes in height	30
Number of concentric sections	8
Number of tubes in concentric sections	480

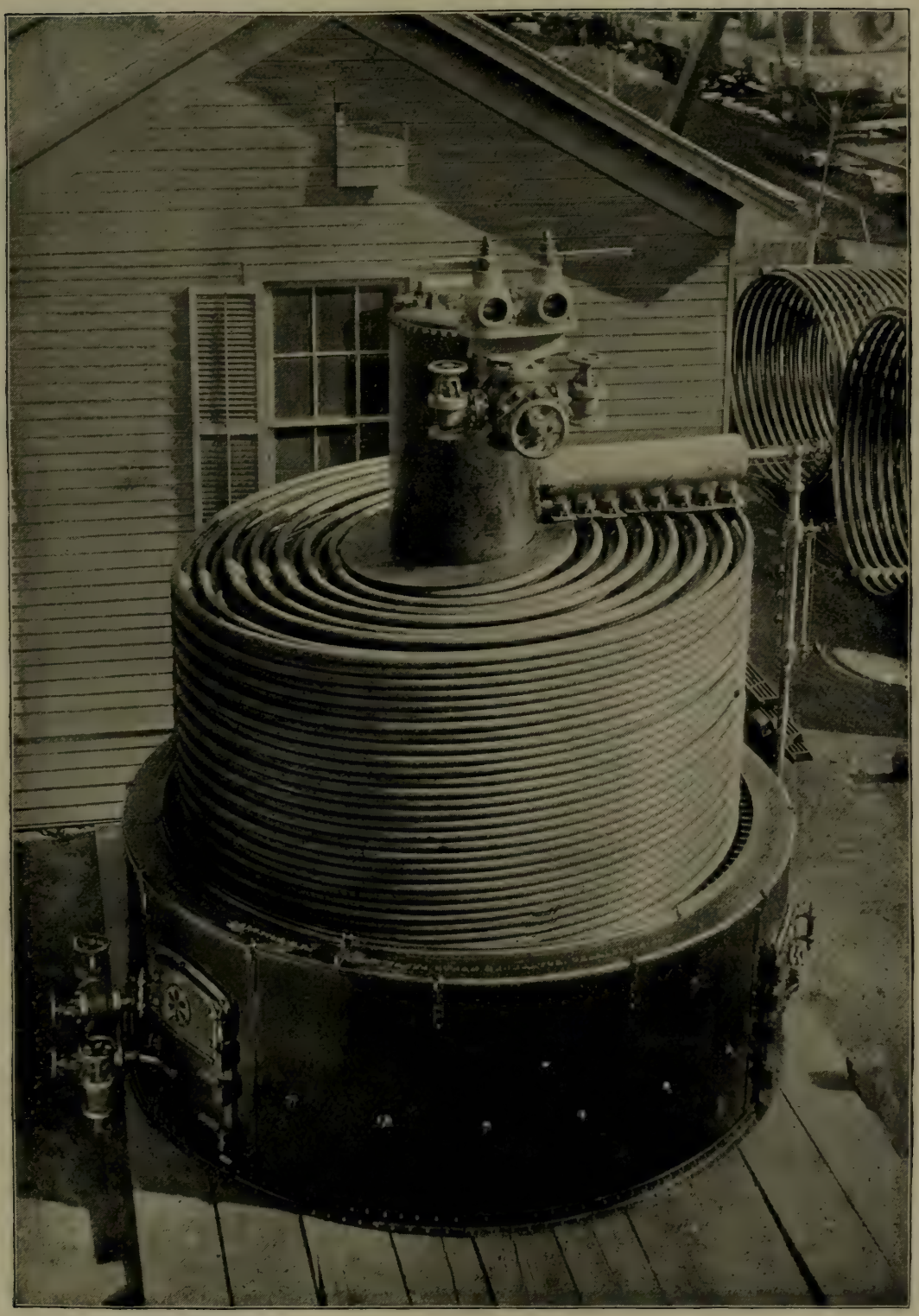


Fig. 1.—THE WARD MARINE BOILER.

Inside diameter of tubes (normal)	inches	1.5
Weight per linear foot	pounds	2.66
Outside diameter of base molding	feet	11.5
Outside diameter of fire box	do	11.08
Outside diameter of casing	do	9.83
Height of casing	do	8.25
Diameter of drum (outside)	inches	28
Height of drum	feet	11.25
Thickness of drum	inch	.3125
Diameter of stop valve	inches	5
Diameter of safety valves (2)	inches	4
Test pressure (hydrostatic)	pounds	300
Steam pressure (working)	do	160
Furnace doors		4
Heating surface, total	square feet	2,490
Grate surface	do	74
Ratio, H. S. to G. S		33.65 to 1

The weight of this boiler, in steaming condition, is 34,720 pounds, or 13.94 pounds per square foot of heating surface, and the total fire room weights, including water in boiler, floor plates, and fittings, 46,821 pounds, or 18.8 pounds per square foot of heating surface.

On a trial in the Delaware River it furnished steam at 160 pounds pressure to a triple-expansion engine for 525 I. H. P., the draft being assisted at intervals by a steam jet.

Monterey—Particulars of one Ward boiler.

Outer diameter of annular grate	feet	10.17
Inner diameter of annular grate	do	3.06
Height of furnace	inches	24
Outside diameter of casing at furnace	feet	11.08
Outside diameter of casing above furnace	do	10.67
Height of casing from floor to cover (about)	do	8.25
Height of central drum from floor (about)	do	11.5
Length of central drum, outside	do	10.75
Diameter of central drum, outside	inches	28
Thickness of metal in drum	inch	.312$_5$
Diameter of through stays in drum (4)	inches	1.25
Height of boiler from floor to top of smoke duct (about)	feet	12.33
Dimensions of smoke duct, inside	do	2.25 by 4.5
Diameter of stop valve	inches	5
Diameter of safety valves (2)	do	3
Test pressure	pounds	300
Number of vertical manifolds, 9 on a side		18
Number of concentric coils		18
Number of tubes in concentric coils		540
Outside diameter of tubes	inches	1.9
Thickness of tubes	inch	.125
Number of coils for each pair of vertical manifold		30
Heating surface, total	square feet	2,970
Grate surface	do	73.81
Volume of steam space	cubic feet	18
Volume of water space	do	86
Area of air passage around coils	square feet	14
Area of uptake	do	10

The weight of the four coil boilers of the *Monterey* with water and all fittings is 13 pounds per square foot of heating surface.

An evaporative test of a boiler similar in all respects to those fitted in the *Monterey* was made by a board of naval engineers at Charleston, W. Va., December 18 and 19, 1889, the result of which is given in the report of the Chief of the Bureau of Steam Engineering for 1890. The boiler tested contained 2,473 square feet of heating surface and 53 square feet of grate, and weighed, empty, exclusive of smoke pipe, 11.845 tons; with water to the first gauge cock, 13.604 tons, and with water to the second cock, 13.851 tons. The tests were commenced and ended with bare grates, and the pressure of the boiler was regulated at 160 pounds by the stop valve of the boiler. The fuel used was New River, W. Va., coal, the analysis of which, as furnished by the agents, was:

	Per cent.
Fixed carbon	70.67
Volatile matter	25.35
Sulphur	.57
Moisture	1.35
Ash	2.10

The following are the official figures of the test:

Duration of test, in hours, 2 of 12 hours each		24
Fuel (Nuttalburgh, New River) consumed	pounds	70,022
Refuse from fuel, in dry ashes, dust, and clinkers	do	3,389
Combustible consumed	do	66,633
Water fed to boiler by tank measurement	do	461,884.6
Per cent. of the fuel in dry refuse, etc		4.838
Temperature in degrees F.—		
Feed water		50.4
Steam, by thermometer		364.33
Uptake		882.83
Atmosphere		72.48
Fire room		75
Pressure of steam in boiler in pounds per square inch above a perfect vacuum, 14.7 + pressure by gauge		174.4
Air pressure in inches of water in fire room		2
Revolutions of blowing engines per minute		273.166
Revolutions of blower per minute		546.333

Rate of combustion.

	Fuel.	Combustible.
	Pounds.	*Pounds.*
Per hour	2,917.583	2,776.375
Per hour per square foot of grate (53)	55.0487	52.3844
Per hour per square foot of heating surface (exterior)	1.1795	1.1224

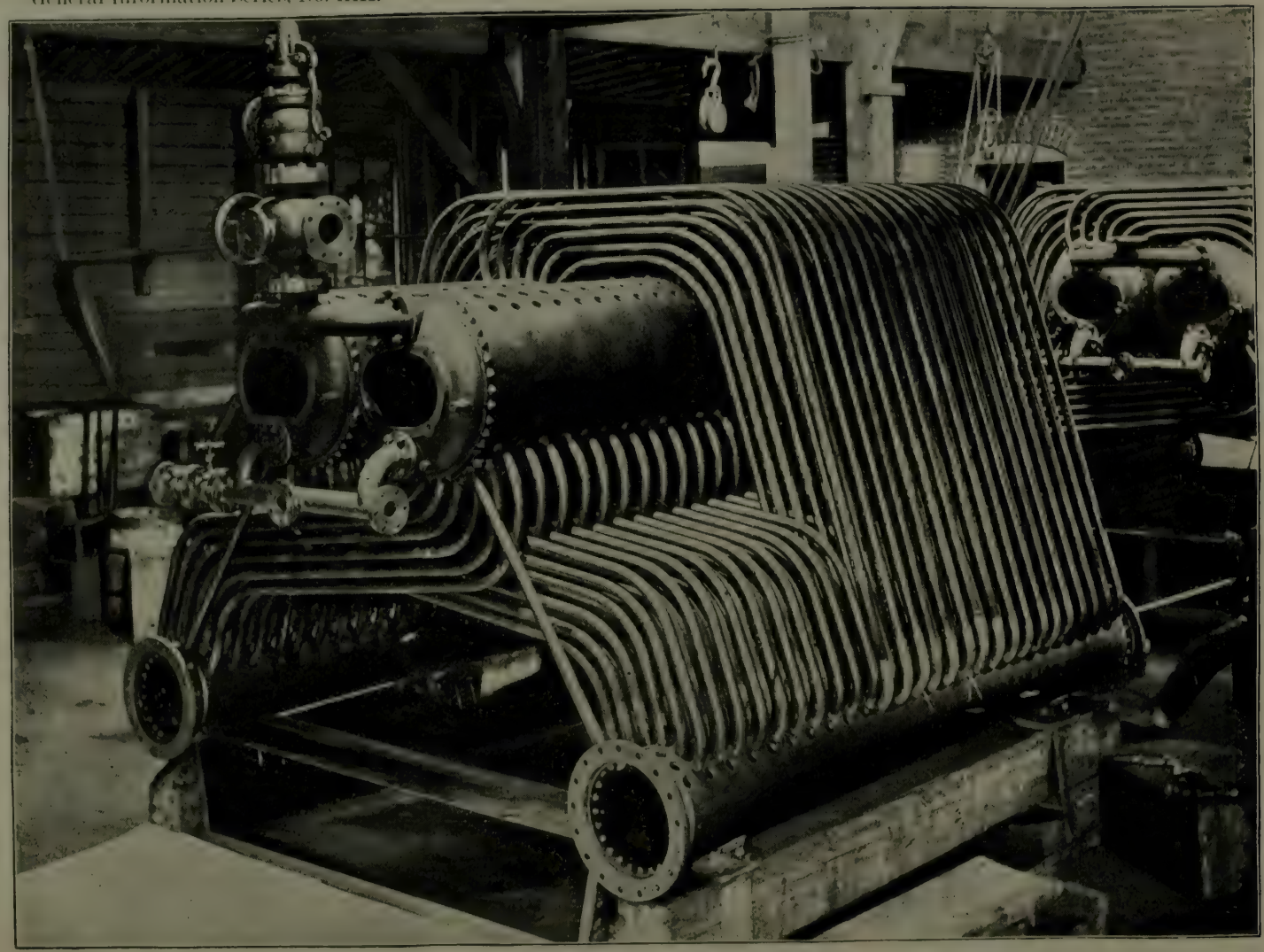


Fig. 2 —THE WARD "UNIQUE" BOILER.

Vaporization of water.

	Per pound of fuel.	Per pound of combustible.
	Pounds.	*Pounds.*
Apparent evaporation, by tank measurement, from the temperature of the feed and under a pressure of 159.7	6.5963	6.9318
Equivalent evaporation from and at 212° and under atmospheric pressure	8.0345	8.4429
Actual evaporation into steam from the temperature of the feed and under the test pressure	5.7729	6.0665
Equivalent actual evaporation from and at 212° and under atmospheric pressure	7.0314	7.3890
Potential evaporation, or evaporation had all the heat from the fuel been utilized in converting the water in the boiler into dry saturated steam from the temperature of the feed and under the test pressure	5.9986	6.3037
Equivalent potential evaporation from and at 212° and under atmospheric pressure	7.3063	7.6779

The average moisture from calorimetric measurements made every hour was 12.482 per cent., but in connection with this the board says:

The very considerable amount of moisture in the steam, as shown by the calorimeter tests, was not evident by any effect produced in the blower engine or feed pump, or in the cylinder of the large steam pump on the river bank, the steam for all of which came from the main steam pipe of this boiler. The steam to the pump on the river was led through an uncovered pipe 200 feet long. To the unaided senses the steam seemed dry, except for an occasional appearance of water at the discharge of the blow-off pipe.

One of Mr. Ward's latest boilers is shown in fig. 2, being what he terms the "Unique" boiler, from the fact that a steamer of that name, building on the Lakes, is to be supplied with two of them, each with 50 square feet of grate and 2,000 of heating surface. It will be seen that one-half the tubes cross from one side to the other below the steam drums and are expanded in the opposite drum, forming an arch above the grate, and that the remainder cross above the drums. The lower tubes are either wholly or partially "drowned," and the feed, which is introduced into a pan in the upper drums, is supposed to flow down the two outer short rows and up the other, Mr. Ward having always maintained that outside circulating pipes are unnecessary. The drums are protected from the direct heat of the furnace by sheet-iron plates, arranged above the arch formed by the lower tubes. There are 12 rows of tubes on each side, each 1.5 inches diameter, made of wrought iron, extra heavy gauge.

These two boilers, in steaming condition, weigh about 18 tons, and are expected to furnish steam at 225 pounds pressure to a quadruple-expansion engine for 1,500 to 1,800 horse-power. Both are in the same compartment, but each has its own smoke pipe; they are arranged for working under forced draft on the closed stokehold system.

The casing of these boilers is 9 feet long, 8 feet high, and 9 feet 6 inches in width.

The two boilers thus far mentioned are the only types that Mr. Ward has fitted in steamers, except those for steam launches, of which there are a number in use in the service. He has, however, built two others of essentially different design, which are illustrated in figs. 3 and 4. The first is known as the "Royal Arch" type, and the following description of it is from a paper by Mr. Ward, in the Proceedings of the International Engineering Congress, Division of Marine and Naval Engineering and Naval Architecture:

WARD'S ROYAL ARCH OR NAVAL BOILER.

It is composed of three piles or sections of tubes arranged as concentric arches, forming a rectangular fire box and combustion chamber. Immediately under the arch is a horizontal drum; at the rear and on top of the drum is a manifold, to which the top central manifold of each arch is connected. From the under side of the drum and at the rear is a downcast circulating connection which crosses over to each side, connecting the lower leg of each arch section and making the circuit. Immediately over the combustion chamber and under the horizontal drum is a nest or section of inclined tubes, forming, as it were, a crown sheet to the furnace; on top of this section is a dead plate, which entirely prevents the intense heat from reaching the drum, and causes the gases of combustion to divide and pass up among the tubes on either side on their way to the smokestack.

It is obvious that on disconnecting any of the three arches they may be drawn out into the fire room for repairs, etc. The illustration shows a boiler of this type having 2,250 square feet of heating surface and 46.5 square feet of grate. It is 9 feet wide, 10 feet deep, 8 feet 6 inches high, and weighs 10 pounds per square foot of heating surface.

The feed is introduced at the front end of the drum, and passes through a pipe therein to the back end, where it is discharged immediately over the down cast.

The second boiler referred to is shown in fig. 4, and is termed the

WARD BRONZE BOILER.

The boiler illustrated has been designed for steam-launch use. The distinguishing feature in it is the front and rear heads, which form the connection between the tubes and the steam drum. Each head is in one casting, of brass, and has the end of the steam drum cast with it. It is a flat, hollow, box-like structure, with openings for one hundred 2-inch tubes. Between each vertical row of tubes there is a parting wall, which stays the outer walls against internal pressure; these parting walls extend to within a few inches of the top and bottom of the casting, so that all the vertical passages are connected at the bottom and top by transverse passages, the upper giving direct connection to the steam drum, and the lower acting as a receptacle for deposit, which may be blown out from a blow-off attachment at the lower side openings.

The boiler is built square, but is set in an inclined position on the ash pan, so that the steam generated is readily delivered into the steam drum.

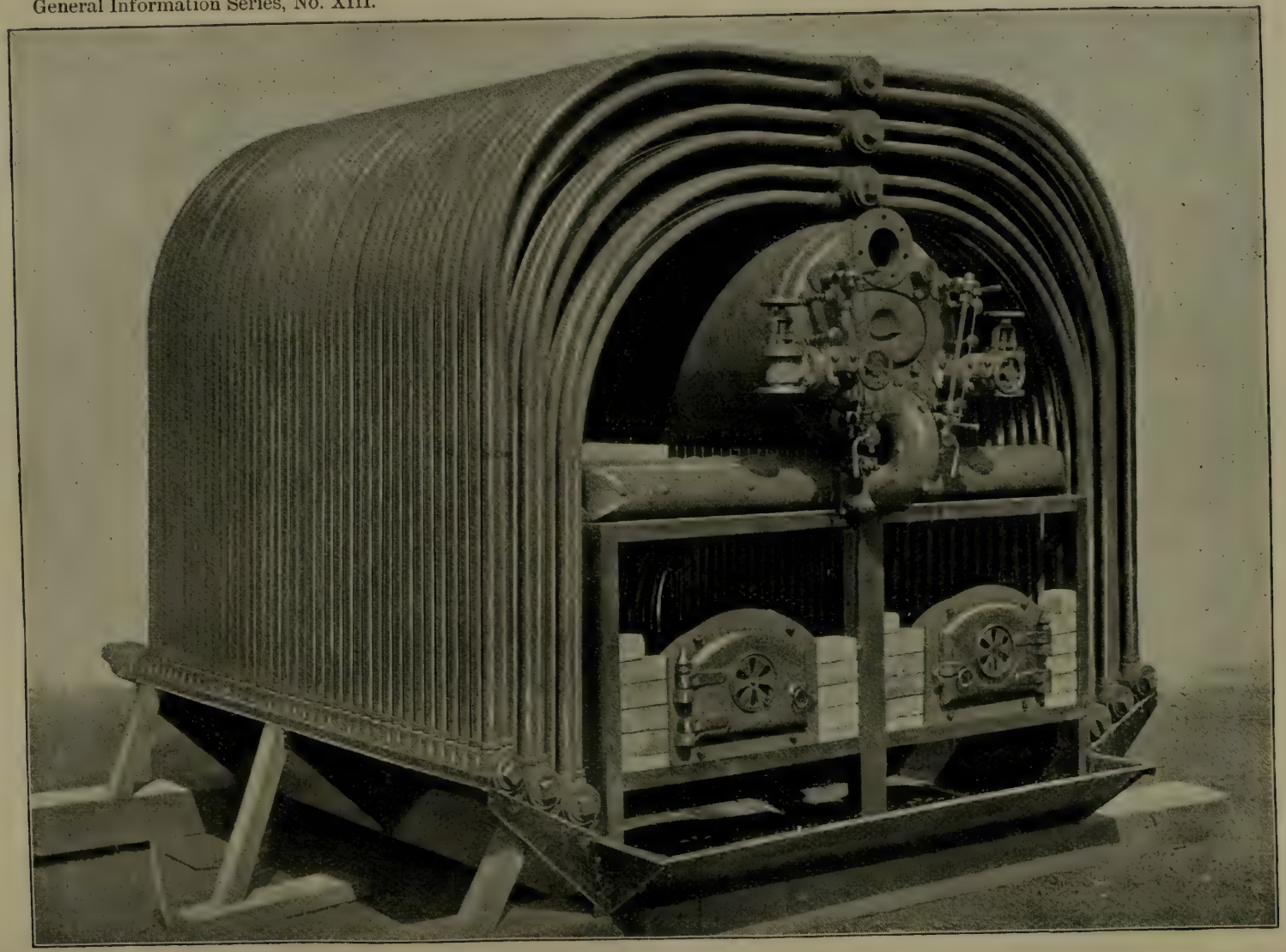


Fig. 3.—THE WARD "ROYAL ARCH" BOILER.

Fig. 4.—THE WARD "BRONZE" BOILER.

The feed water enters at the front of the steam drum and is conveyed to the rear and lower end of the drum, where it is discharged into the back head, and thus supplies the inclined tubes. The lower ends of all the tubes are expected to receive solid water, while the upper end of the upper tubes may be above the water line. By removing the brass plug opposite the end any tube may be removed or renewed.

This boiler has been tested to 300 pounds water pressure. It contains 7.6 square feet of grate, 174 of heating surface; weighs 2,000 pounds empty, and 2,365 pounds with water, or 13.6 pounds per square foot of heating surface.

THE MOSHER BOILER.

This boiler, a type of which is shown in figs. 5 and 6, was first brought to public notice by the remarkable speed made by the *Norwood*, a small yacht belonging to the late Mr. Norman L. Munro. The boiler in this boat was 6 feet wide, 7 feet 3 inches long, and 3 feet 6 inches high, and contained 26 square feet of grate, and 1,000 of heating surface. It weighed 5,600 pounds, and is said to have furnished steam at 200 pounds pressure to a triple-expansion engine for 450 I. H. P. The engine was 9, 14½, and 22 inches diameter by 9 inches stroke, and ran at 500 revolutions per minute. From this it would appear that the I. H. P. was not as much as 450, but the performance of the boat was such a remarkable one as to bring the boiler into prominence as a water-tube boiler. Its next appearance was in the *Feiseen*, a remarkably fast yacht, built by Gardiner & Mosher for Mr. W. B. Cogswell, of Syracuse, N. Y. This boiler had 33 square feet of grate and 1,100 of heating surface, and is said to have furnished steam to a quadruple-expansion engine for 600 horse power.

The boiler shown in fig. 5 is for the second-class torpedo boat of the *Maine*. It has 12.6 square feet of grate, 485 of heating surface, and weighs, with all fittings and water to steaming level, 4,130 pounds.

In fig. 7 is shown a type of this boiler, such as has been designed for a vessel of the torpedo-cruiser type. It contains 60 square feet of grate and 3,015 of heating surface, and weighs, with all fittings and water to working level, 31,230 pounds, with tubes 1.25 inches diameter and No. 12 B. W. G., or 33,580 pounds, with tubes No. 10, B. W. G.

As will be seen, the Mosher boiler possesses many features in common with the first type of Thornycroft boiler, but is superior to it in many respects. In the first place it stows better in a boat, and is, therefore, more economical of space; its center of gravity is lower; the steam drums are practically outside the boiler casings, and consequently removed from the heat of the furnace; there are two steam drums, each with its down pipes, which practically makes it a double boiler, rendering it possible, in case of the bursting of a tube on one side, to steam with one-half the boiler in an emergency.

In the latest type of this boiler (fig. 7) the circulation of the feed

water is down the two outer rows of staggered tubes on each side and up the others; this feature has only recently been introduced, the boilers hitherto used having had outside circulating pipes, as in the Thornycroft boiler.

Boilers of this type are to go in a fast yacht, 100 feet in length, which Messrs. Gardiner & Cox are designing for a speed of 30 miles an hour.

In the Proceedings of the International Engineering Congress Mr. Mosher gives the following result of the test of one of these boilers by Prof. Denton, of Stevens Institute:

The boiler was one with outside circulating pipes.

The test was made to determine the most economical performance at a moderate rate of combustion with Pocahontas semi-bituminous coal. The draft was produced by a steam jet, which caused a suction of one-fourth of an inch of water at the base of the chimney. The method of starting the test was to bring the boiler to regular action with wood, and then to draw the fire and start a new one with a weighed amount of wood followed with weighed amounts of coal. At the end of eight hours the fire was allowed to burn out so that the chimney temperature was falling, and then all material on grates was weighed as ashes. The results were as follows:

Duration of test	hours	8
Heating surface	square feet	1,108
Grate surface	do	33
Total coal fed to furnace, including equivalent of wood	pounds	1,880
Coal per hour	do	235
Coal per square foot of grate per hour	do	7.1
Water evaporated at 185 pounds pressure from 73° F	do	17,143
Water per hour at 185 pounds pressure from 73° F	do	2,143
Horse power with triple-expansion engine, at 15 pounds per H. P		150
Temperature in chimney	degrees F	443
Water evaporated in ash pan	pounds	100
Air entering ash pan by anemometer, per pound of coal	do	19
Draft pressure, base of chimney, inches of water		.25
Average boiler pressure above atmosphere	pounds	185
Temperature of feed water	degrees F	73
Water evaporated per pound of coal at 185 pounds and 73°	pounds	9.12
Per cent. of priming by Barrus superheating calorimeter		1.5
Water evaporated per pound of coal from and at 212°	pounds	10.92
Water per pound of combustible from and at 212°	do	11.7
Per cent. of ashes		7

The total heat of combustion of the coal used for the above per cent. of ashes was determined by a calorimeter test to be 13,900 British thermal units. The heat of the coal was therefore distributed as follows:

	Per cent.
Useful effect evaporating water, or efficiency	76
Escaping through chimney	13
Wasted in hot ashes	1.6
Wasted evaporating water in ash pan	.3
Lost by radiation, etc	9.1
	100

The results are excellent, considering the exposed condition of the exterior of the boiler. The efficiency obtained, even under these circumstances, is above the average performance of good boilers.

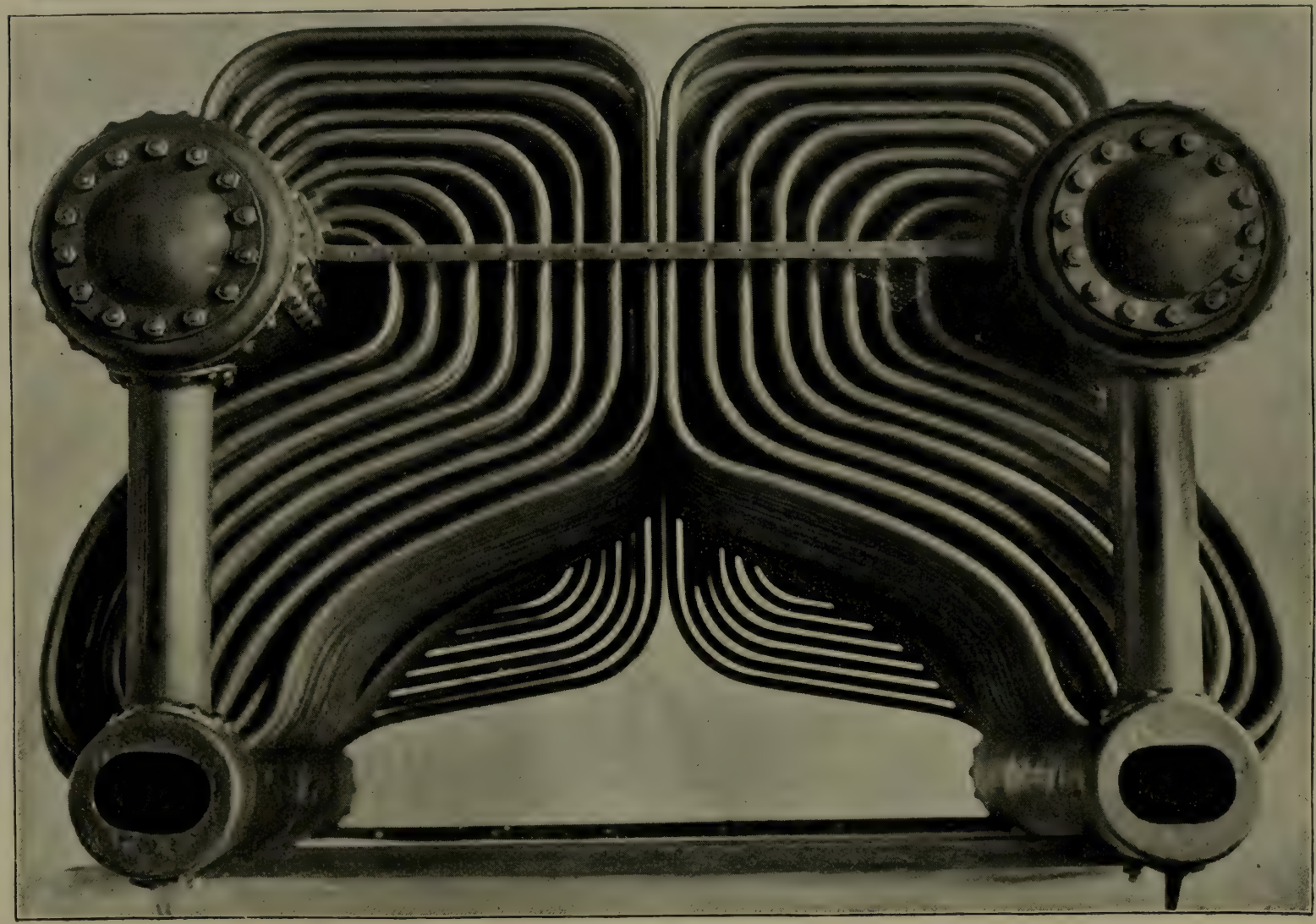


Fig. 5.—THE MOSHER BOILER.

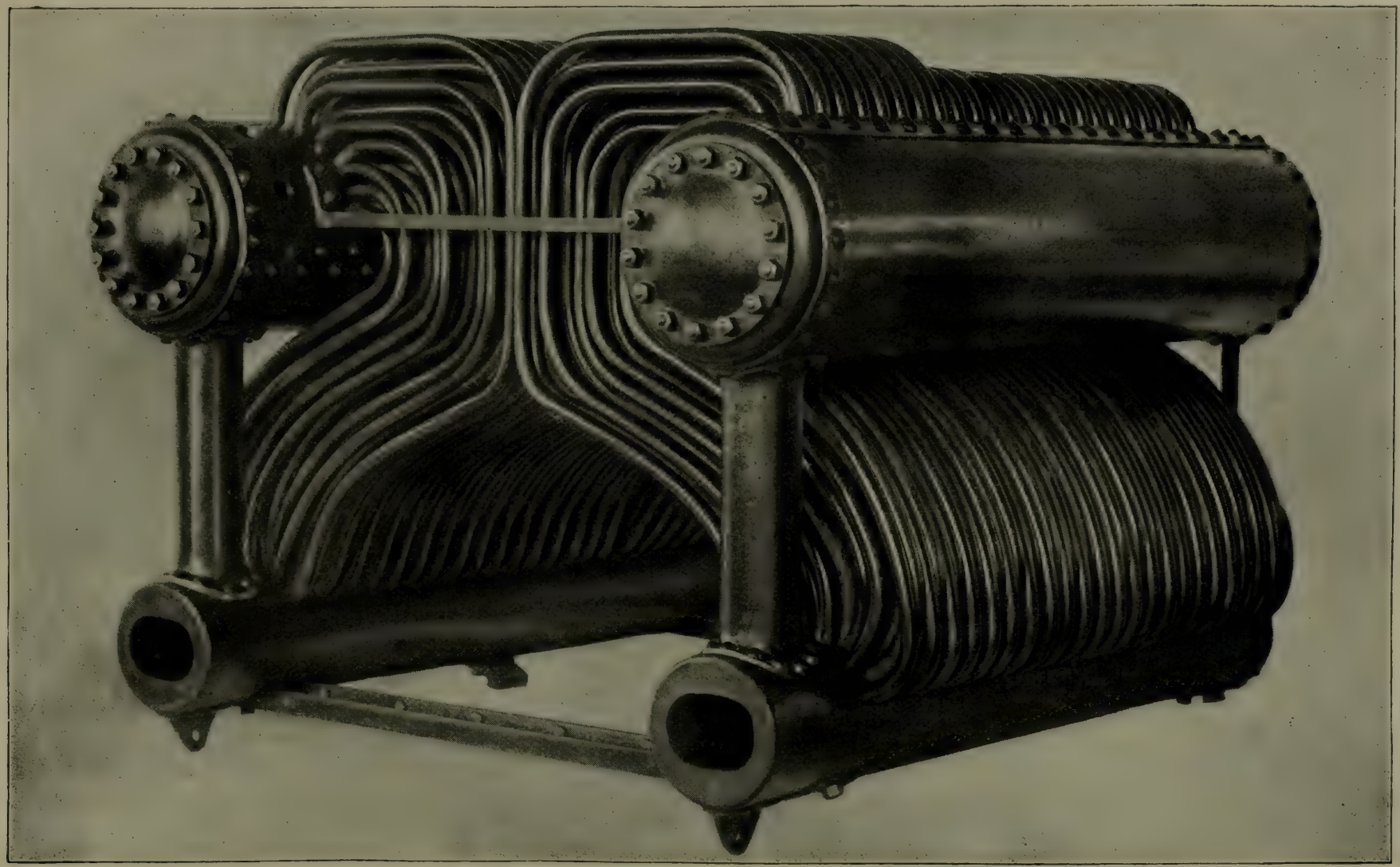


Fig. 6.—THE MOSHER BOILER.

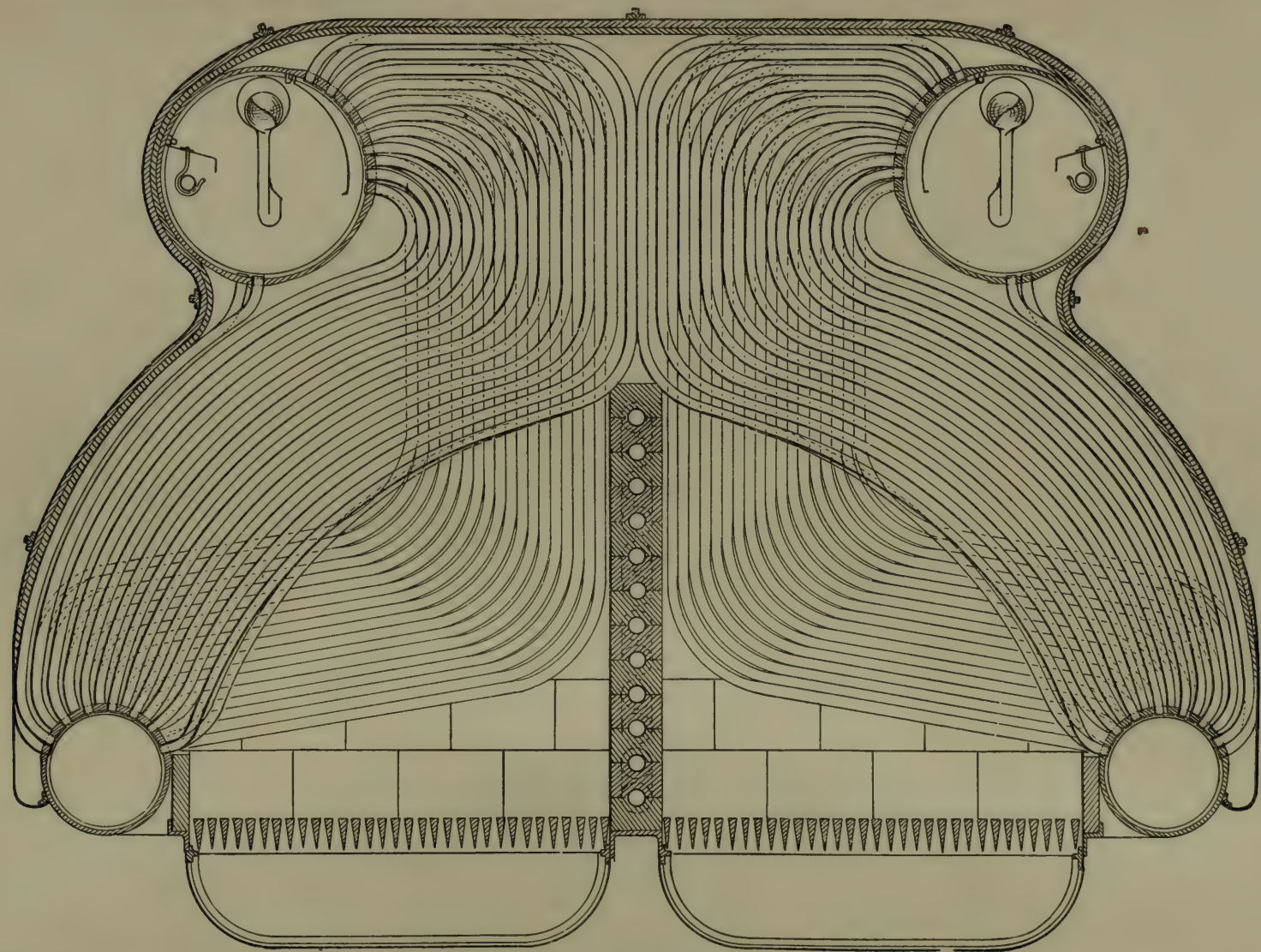


Fig. 7.—THE MOSHER BO .ER.

There were no special arrangements made for these tests; the boiler was wholly exposed to the atmosphere; the ends of the steam drums, the return pipes, the cross pipes, and the water drums were not lagged or protected from radiation in any way. The fireman had never had any experience with this type of boiler previous to these tests.

Mr. Mosher also stated that in a more recent test by Prof. Denton on a boiler with 1,100 square feet of heating surface, an evaporation of 8.5 pounds of water was obtained from a feed temperature of 60° into steam of 250 pounds pressure, with an air pressure of 2.5 inches of water; and that the percentage of moisture was only 1.5, and the chimney temperature 520°. He also stated that under an air pressure of 12 inches of water an evaporation of 18.2 pounds per square foot of heating surface was obtained, with less than 2 per cent. of moisture.

THE ROBERTS BOILER.

This boiler, illustrations of which are shown in figs. 8, 9, 10, and 11, is in use in a number of steam launches, yachts, and other craft. As will be seen from the illustration, it is rectangular in form, with a horizontal cylindrical drum at the top and center of the boiler, connected at each end with horizontal water pipes, which supply the lower side pipes and the upflow coils. Fig. 8 shows a skeleton of the boiler without any of the upflow pipes, and fig. 9 one with the addition of two coils, one on each side of the boiler. It will be observed that the opposite coils break joints with each other, and that each enters the lower surface of the drum on the opposite side from the side pipe from which it started. Fig. 10 shows the boiler with all the upflow coils in position, and fig. 11 the boiler complete, except the casing.

The operation of the boiler is as follows: The feed water is delivered into a diaphram T in front of the drum, whence it passes through a heating coil on each side of the drum, (shown in cut No. 11)—the pipes in horizontal planes. After leaving these coils it is delivered into the drum at a point a little above the water line, and thence flows into the large horizontal pipes, down the end pipes to the longitudinal pipes, and up the coils into the drum. Here the steam and spray enter a dry pipe in the upper part of the drum, which pipe connects at each end with one of the superheating coils shown at the sides of the boiler in cut No 11. These superheating coils unite at the front end of the drum, where the connections are made for the engine, safety valve, etc.

The T's connecting the side pipes with the large downflow pipes have sediment pockets at each end. The cross pipes, side pipes, elbows and T's are malleable steel castings, the side pipes being increased in thickness in order to get a good thread for the upflow pipes. The holes in the drum and in the side pipes are tapped left-handed, and so it is an easy matter to disconnect any coil. Each coil has a slightly upward pitch in order to facilitate circulation.

One of these boilers is in the yacht *El Primero*, built by the Union

Iron Works, San Francisco, for Mr. E. W. Hopkins. A description of it, and a report of the trial of the yacht are given in the Journal of the American Society of Naval Engineers, from which the following is taken:

Dimensions of Roberts boiler, No. 13.

Width over all	feet	7
Length over all	do	8
Height from bottom of sediment pockets to top of jacket	inches	[1]74
Internal diameter of upflow coils	do	1.5
Internal diameter of feed coils	do	1.25
Internal diameter of superheating coils	do	2.5
Internal diameter of downflow pipes	do	5
Internal diameter of side pipes	do	[2]5
External diameter of steam drum	do	24
Thickness of steam drum	inch	.4375
Thickness of drum heads	do	.5
Heating surface in all upflow coils (external)	square feet	576
Heating surface in both feed coils (external)	do	367
Heating surface in both superheating coils and connections (external), square feet		92
Heating surface in both side pipes (external, figuring half circumference), square feet		9
Heating surface in all downflow pipes (external, figuring full circumference)	square feet	36
Heating surface in steam drum (external, full circumference)	do	40
Heating surface in both drum heads (total area)	do	6
Total heating surface in boiler	do	1,126
Total grate surface	do	35.33
Boiler, as weighed for freight by railroad company, net	pounds	13,000
Calculated weight of water to steaming level	do	1,556
Total	pounds	14,556

This weight includes casing, grates, firebrick, magnesia filling, and all small fixtures, but not smokestack or ash pan.

The dimensions of the yacht are:

Length—on load water line	feet	105
over all	do	137
Beam—extreme	do	18
on water line	do	16
Depth	do	8.58
Draught, mean	do	4.58
Displacement	tons	73.48

She was tried over a measured base 2.1252 statute miles in length in San Francisco bay, and made 15.667 miles (13.6 knots). The boiler furnished steam at 204 pounds pressure to a triple-expansion engine 8, 12, and 20 by 12 inches stroke, for 236 I. H. P., the engine making 340.6 revolutions. This amounts to 55 pounds of boiler per I. H. P.

[1] This does not include depth of ash pit, but there are about 6 inches vertical height between bottom of sediment pockets and top of grates.

[2] Scant.

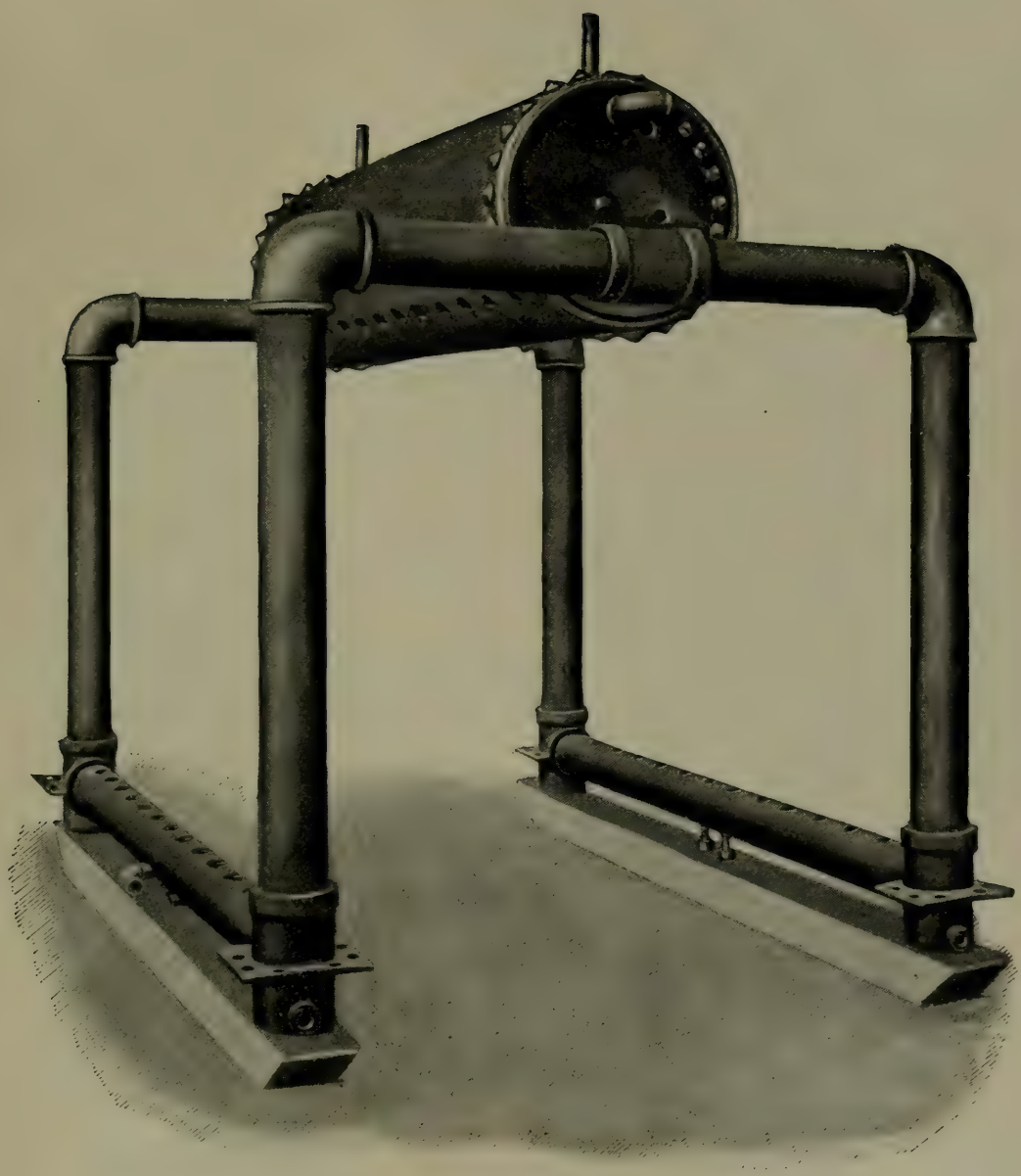
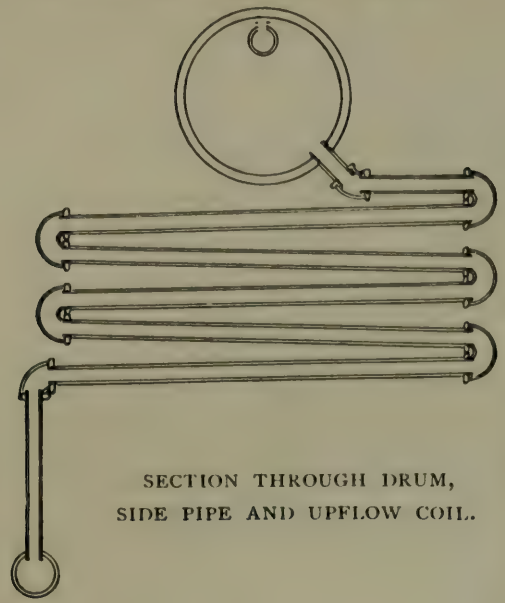


Fig. 8.



SECTION THROUGH DRUM,
SIDE PIPE AND UPFLOW COIL.

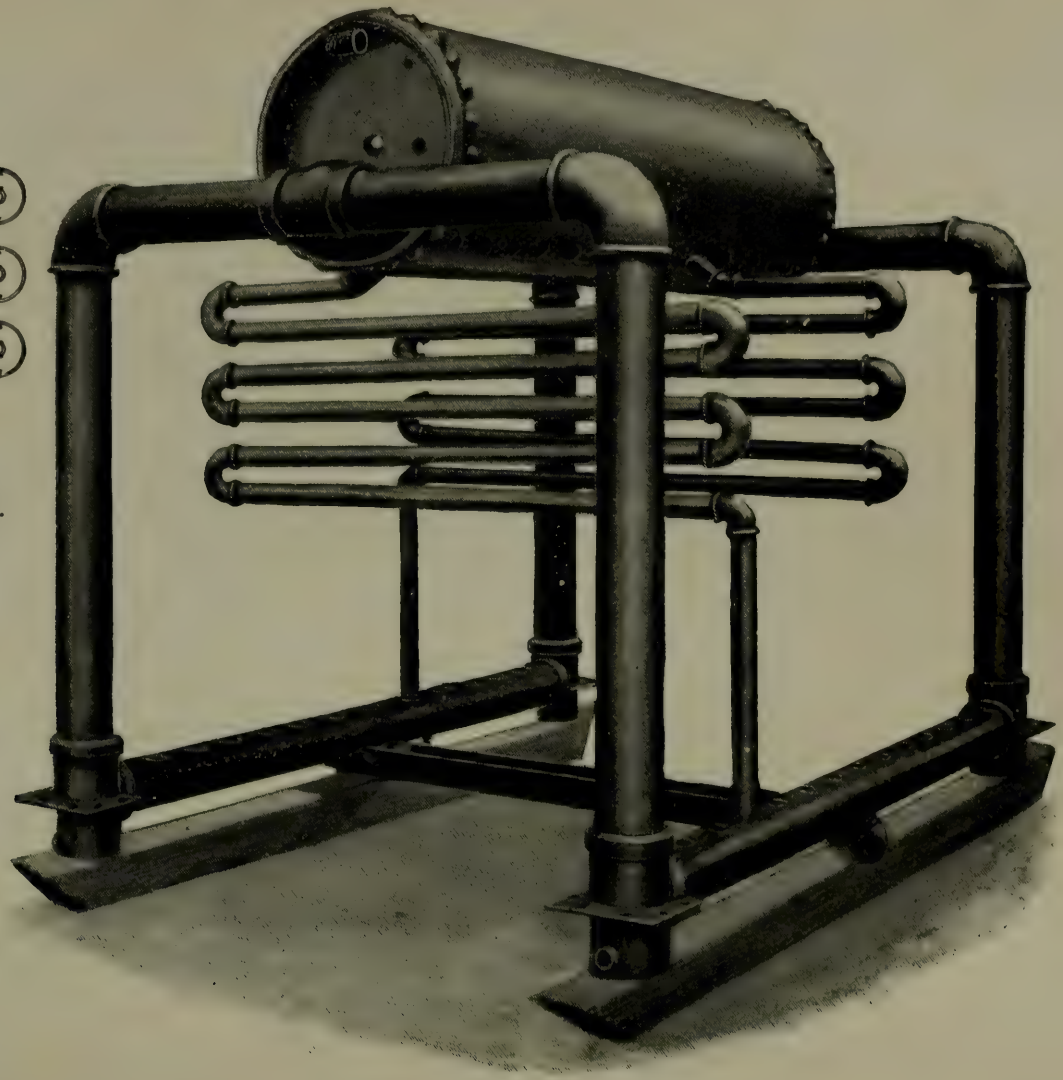


Fig. 9.

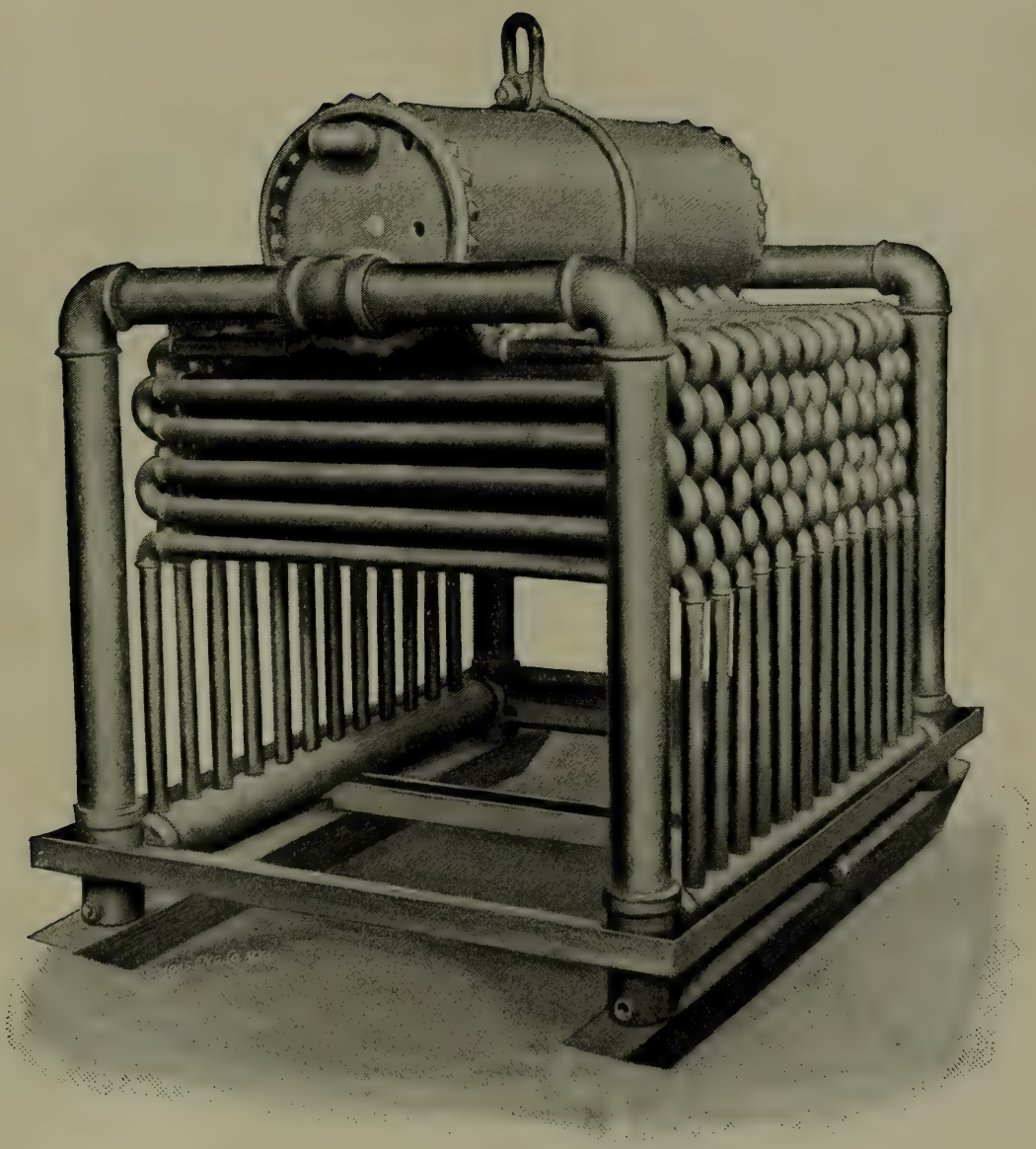


Fig. 10.

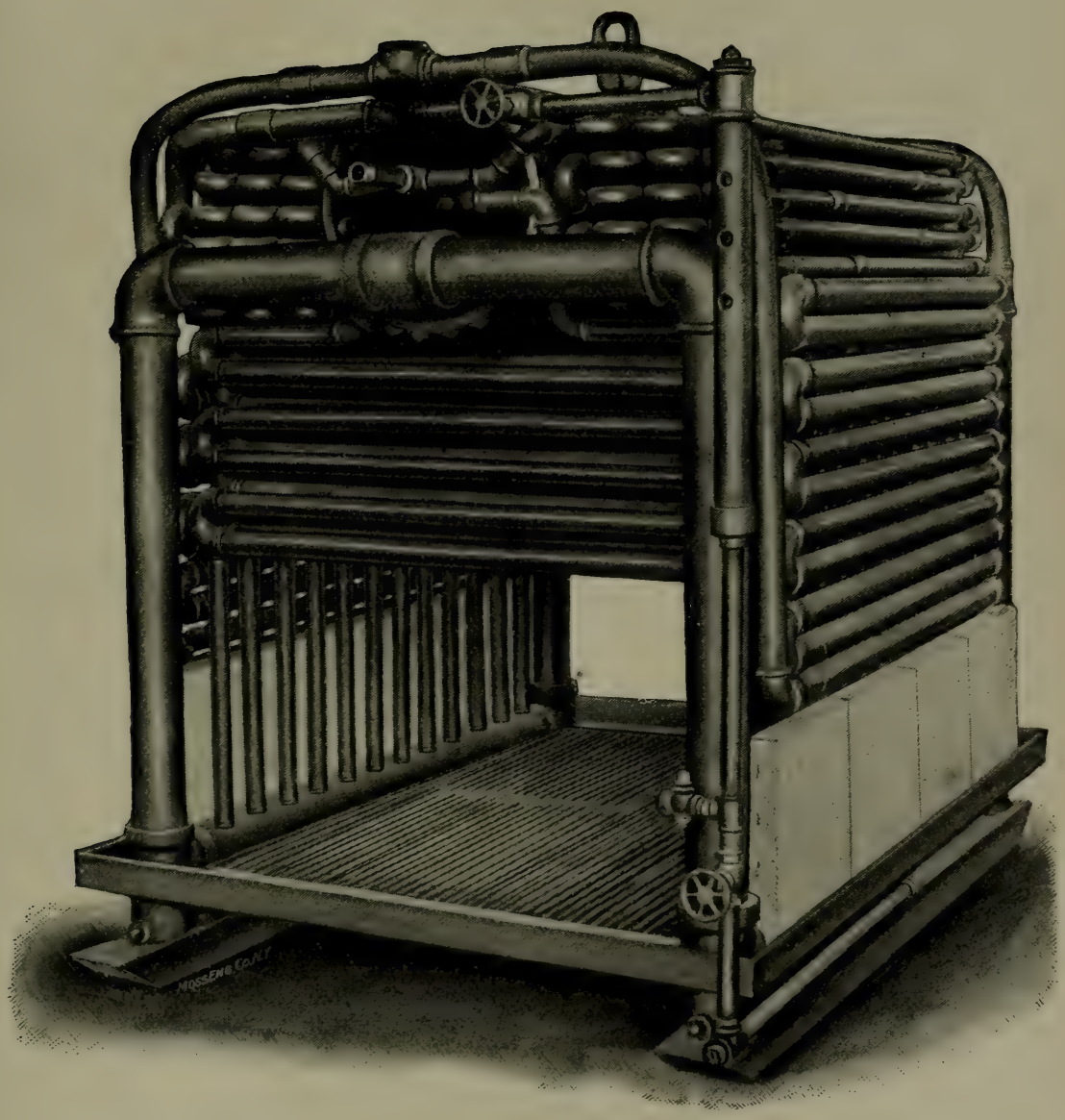


Fig. 11.

THE ALMY BOILER.

This is another pipe boiler built throughout with screw joints. It is represented in figs. 12 to 14, the latter being the boiler in the torpedo boat *Stiletto*. Fig. 12 represents the single-tube type and fig. 13 the double-tube type, the principle of the design being the same in each. The boiler is rectangular in shape, the base being formed by a pipe or manifold extending along each side and at the back of the boiler below the grate. From this manifold a series of pipes rises in pairs at the side, as shown, to Y fittings along the side of the boiler, which latter are connected, by union joints, with short pipes screwed into the upper or steam manifolds on the side. These in turn are connected at the front with another manifold, which receives the ends of the pipes which start from the water manifold at the back of the boiler. These pipes are run similarly, but at right angles to the pipes from the side which form the top of the furnace. This is clearly shown in fig. 12.

The construction of the double-pipe boiler shown in fig. 13 is similar, except that the Y fittings receive four pipes, and that the pipes from the back of the boiler do not return before reaching the fitting below the union, and that in the double-furnace double-pipe boiler there are one or more water manifolds at the center of the boiler below the grate.

The upper manifold connects at the front with a vertical separator, which, in turn, is connected with two horizontal water drums at the front of and outside the boiler casing. The bottom of the vertical separator is connected to the water manifolds by pipes extending across the front of the boiler, as shown in the cut of the *Stiletto's* boiler (fig. 14).

Above the upper manifold there is a feed-water heater, one end of which connects with the bottom of the vertical drum, or with the down-flow pipes. In running, the water level is carried at about the middle of the horizontal drums.

The boiler of the *Stiletto* has now been in her three years, during which time it has given satisfaction. It replaced a Herreshoff boiler, 13 inches longer. The vertical separator is generally made longer than the one shown in the *Stiletto's* boiler, but there it was necessary to shorten it in order to get it beneath the deck.

The following are the principal dimensions of this boiler:

Length outside of casing	feet	6.62
Width outside of casing	do	6.62
Height from bottom of ash pan to top of hood	do	7
Diameter, outside, of steam drum	inches	15
Diameter, outside, of water manifold	do	5.5
Grate surface	square feet	29.5
Heating surface	do	1,020
Weight, estimated, with fittings, except smoke pipe	pounds	11,700
Weight of water	do	1,500

The boiler formerly in the *Stiletto* had 21 square feet of grate and 552 square feet of heating surface.

The engines of the *Stiletto* have never been indicated since this boiler has been in use; it is rated at 350 horse-power, and the makers claim that it is capable of furnishing 450 I. H. P. The steam pressure in ordinary natural-draft running is about 120 pounds, and with forced draft from 140 to 160.

This type of boiler is in use in a number of yachts and launches, and in a few larger steamers. There are two of them in the yacht *Formosa*, and on a recent trial with an inferior quality of anthracite coal they furnished steam to a triple-expansion engine for 804 I. H. P. for two hours, besides running a blower and air and circulating pump engines. The two boilers contain 62 square feet of grate and 2,394 of heating surface, and weigh 35,299 pounds without water, and 38,499 with water. They occupy a space, measured over casings, 6.86 feet long, 13.75 feet wide, and 7.33 high to base of hoods.

THE TOWNE BOILER.

This boiler, which was illustrated in General Information Series No. IX, has been extensively used in steam launches in our service, and is also fitted as an auxiliary boiler on board the revenue cutter *William Windom*. The boiler there fitted has 9.4 square feet of grate and 259 of heating surface, with a drum 18 inches in diameter and 4 feet 8 inches long.

THE SEABURY BOILER.

This is another boiler which is meeting with more or less favor for use in steam launches and yachts. It consists of a steam drum and two water drums, or manifolds, arranged similarly to those in the Thornycroft boiler, with outside circulating pipes. Above the grate, and forming the top of the furnace, are a number of cross-pipe manifolds, their ends connected with the water drums below by vertical pipes. Upright pipes with solid ends welded in are screwed into the cross manifolds and extend to about the level of the bottom of the steam drum; inside these upright pipes are small ones with open ends, the lower of which is screwed into small pipes running through the cross manifolds to the side of the boiler, where they are joined to pipes running up the side and across to the upper part of the steam drum. All the joints are screwed.

The circulation is as follows: The feed water is introduced into the bottom of the steam drum, flows down the outside circulating pipes to the lower manifolds, up the side pipes to the cross manifolds, and thence into the upright closed pipes, into the small internal pipe to the small pipe in the cross manifolds, whence it reaches the steam drum through the small side pipes. The water level is carried below the top of the internal pipe in the upright ones connected with the cross manifolds.

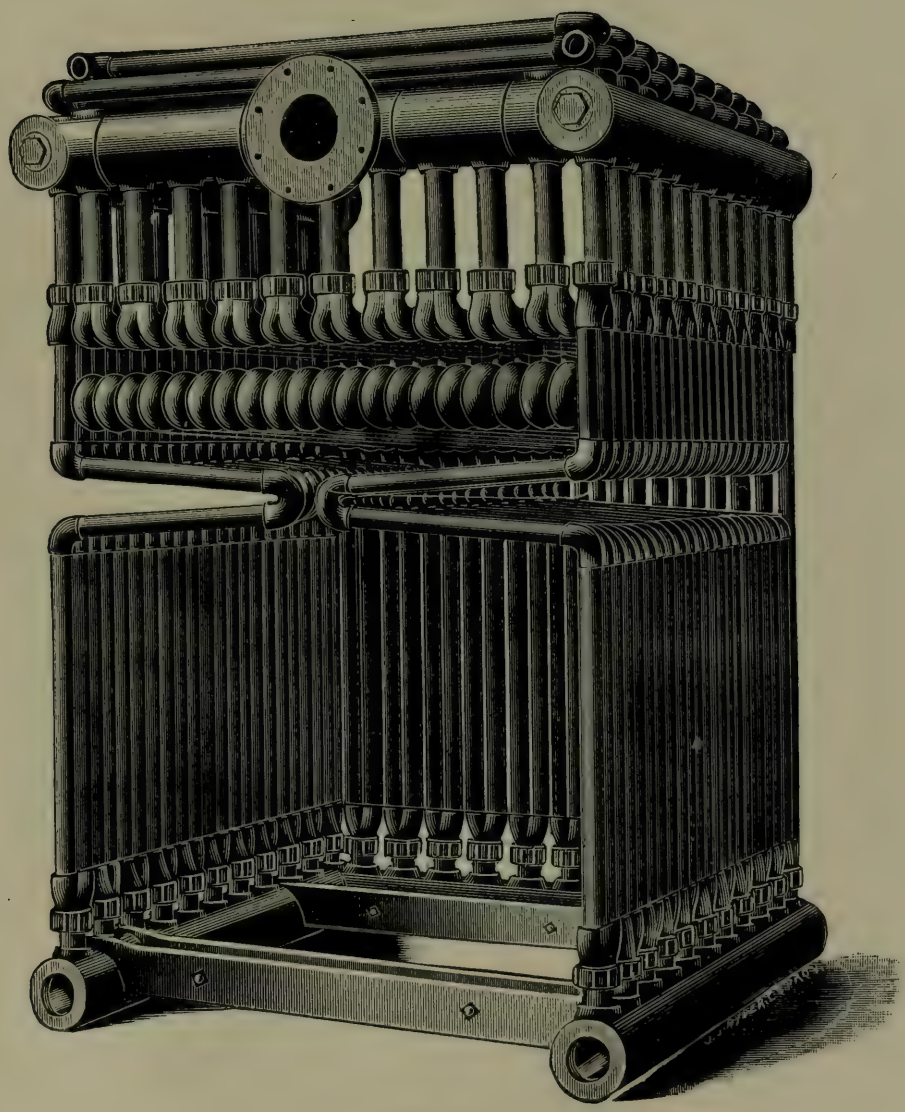


Fig. 12.

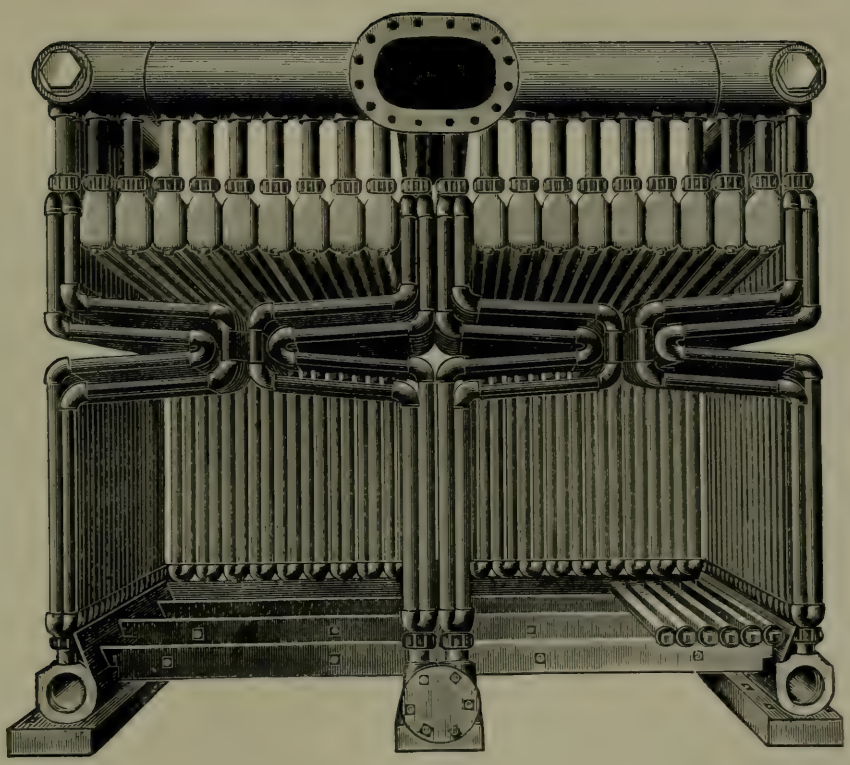


Fig. 13.

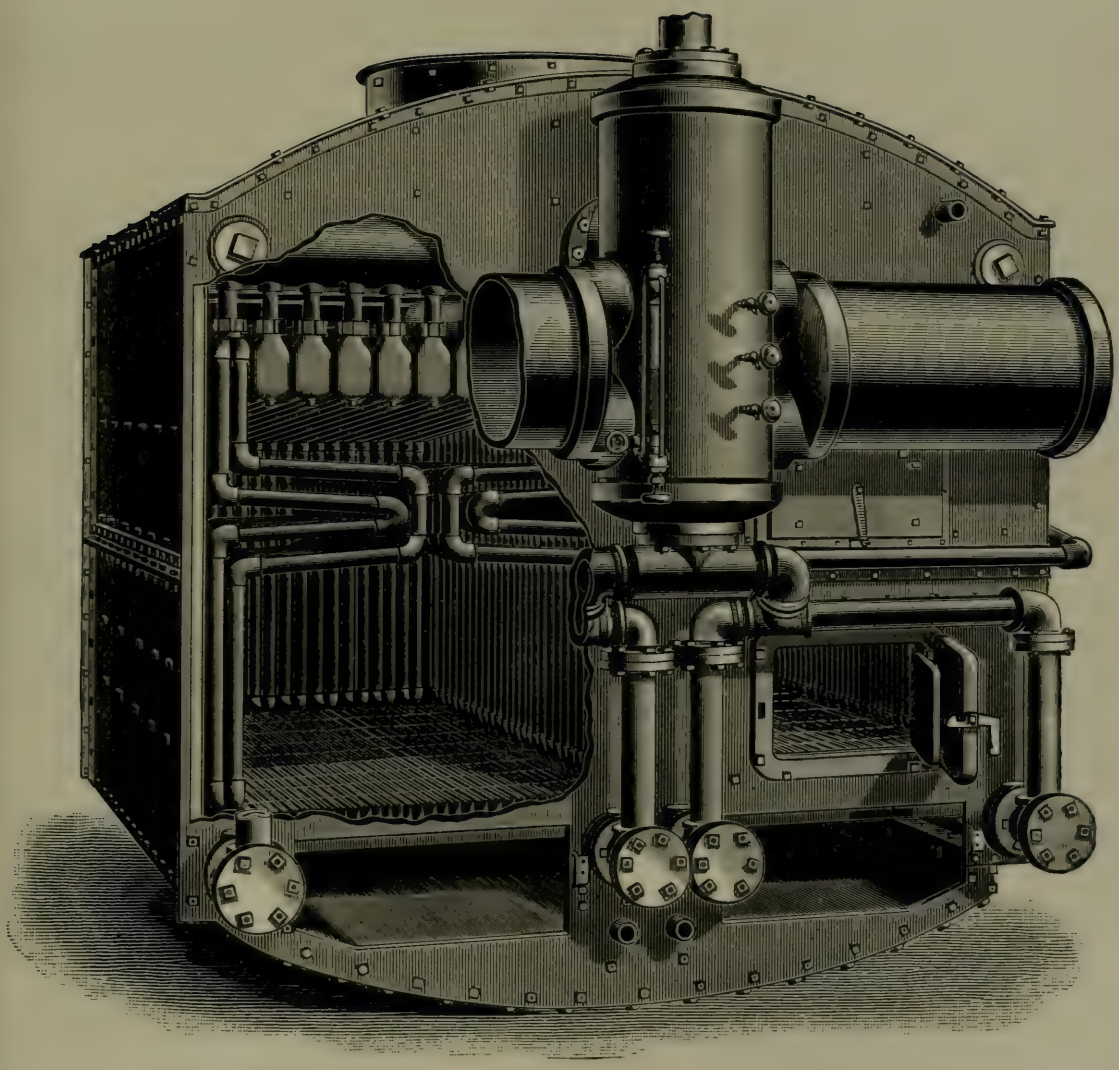


Fig. 14.

THE M'BRIDE AND FISHER BOILER.

This boiler has thus far been used in but one small boat or launch, but the speed of the boat, the *Yankee Doodle*, has been such as to draw attention to the boiler. It is very much like one-half of a Mosher boiler turned through 90 degrees, the water drum being at the back of the grate instead of alongside it. There is also a chamber at the back for cleaning. It has some of the good points of the Mosher boiler, but is objectionable for anything but small boats, on account of the additional length required for the cleaning chamber at the end. Besides, it is not as easy to plug a leaky tube in it as in the Mosher, on account of the steam and water drums running athwartships.

THE WARRINGTON BOILER.

This is a water-tube boiler, which is in use in yachts and launches on the Lakes, and contains a much greater proportion of water than is usual in boilers of this type. It consists of one or more vertical water drums at the back end of the grate, from which L-shaped tubes run to the underside of one or more horizontal steam and water drums above the top of the water drums, and extending from the front of the casing back about half the length of the grate. The tubes which connect with the vertical drum are slightly inclined, so as to give a free rise to the ascending column of water. The gases escape at right angles to the direction of flow of water in the tubes. All tubes are expanded. The steam and water drums are further connected by a large pipe riveted to each drum. The water level is carried above the top of the tubes in the steam drum.

Thus far this boiler has been built only in what is known as "commercial" sizes, that is, with comparatively large water drums, and an idea of its proportions may be found from the following figures for a No. 40 boiler:

Grate surface	square feet	40
Heating surface	do	1,200
Length	feet	8.17
Width	do	7.00
Height	do	7.83
Number of water drums		3
Diameter of water drums	inches	22
Weight in steaming condition	pounds	23,500

THE BABCOCK AND WILCOX BOILER.

Although this boiler has for years been extensively used on shore, it is only recently that the makers have made any efforts looking to its use in seagoing vessels. The latest type for marine purposes is shown in figs. 15, 16, and 17, which has been designed for a cargo boat. It follows the well-known principle of design of former types of this boiler, except that the sides of the boiler and furnace are formed by water

tubes, and that a change has been made in the size and arrangement of the tubes. The five lower rows of tubes immediately above the grates are 4 inches in diameter, and those above 2 inches in diameter, the latter arranged in groups of four each, each of which groups is accessible through a single opening in the headers.

The headers are sinuous in form, as shown in fig. 16, so that the front and back of the boiler is practically a solid water wall, and the tubes staggered. One feature of the construction of these headers is that they are now made of open-hearth steel and hydraulic forged from rolled plate; the ends are welded in, and the two tiers of headers connected together and to the drum and the lower circulating pipes by wrought-iron tubes secured by expanding in the usual way. The main tubes are also expanded in the headers, there being no screw joints in the boiler. Access to the ends of the tubes is had by means of a plate on the front and back headers, one plate for each 4-inch and one for each nest of four 2-inch tubes. The joint on the outside of the header is a ground one, and the dog carrying the stud, which is placed inside the header, is so made that in the event of the stud breaking there will be only a slight leakage.

The plate riveted to the drum to receive the ends of the tubes connecting the back headers with the drum is of open-hearth steel forged to shape in a hydraulic press.

Above the boiler proper there is a feed-water heater, so arranged that it may be shut off and the feed introduced directly into the drum.

The boiler illustrated is of the following dimensions:

Height to—		
Top of feed-water heater	feet	14.25
Bottom of feed-water heater	do	11.5
Center of drum	do	11
Top of drum	do	13
Length over all	do	10
Tubes:		
4-inch		70
2-inch		280
Length	feet	7
Feed-water heater:		
Tubes		184
Diameter of tubes	inches	2
Length of tubes	feet	3
Length of grate	do	5.75
Width of grate	do	8.5
Grate surface	square feet	48.9
Heating surface	do	1,970
Weight of—		
Water, per square foot of H. S	pounds	6
Boiler in steaming condition, per square foot of H. S	do	27

The makers also get out a similar design with fire brick on the sides of the furnace instead of the water tubes, the weight of which, in steaming condition, is 28 pounds per square foot of heating surface.

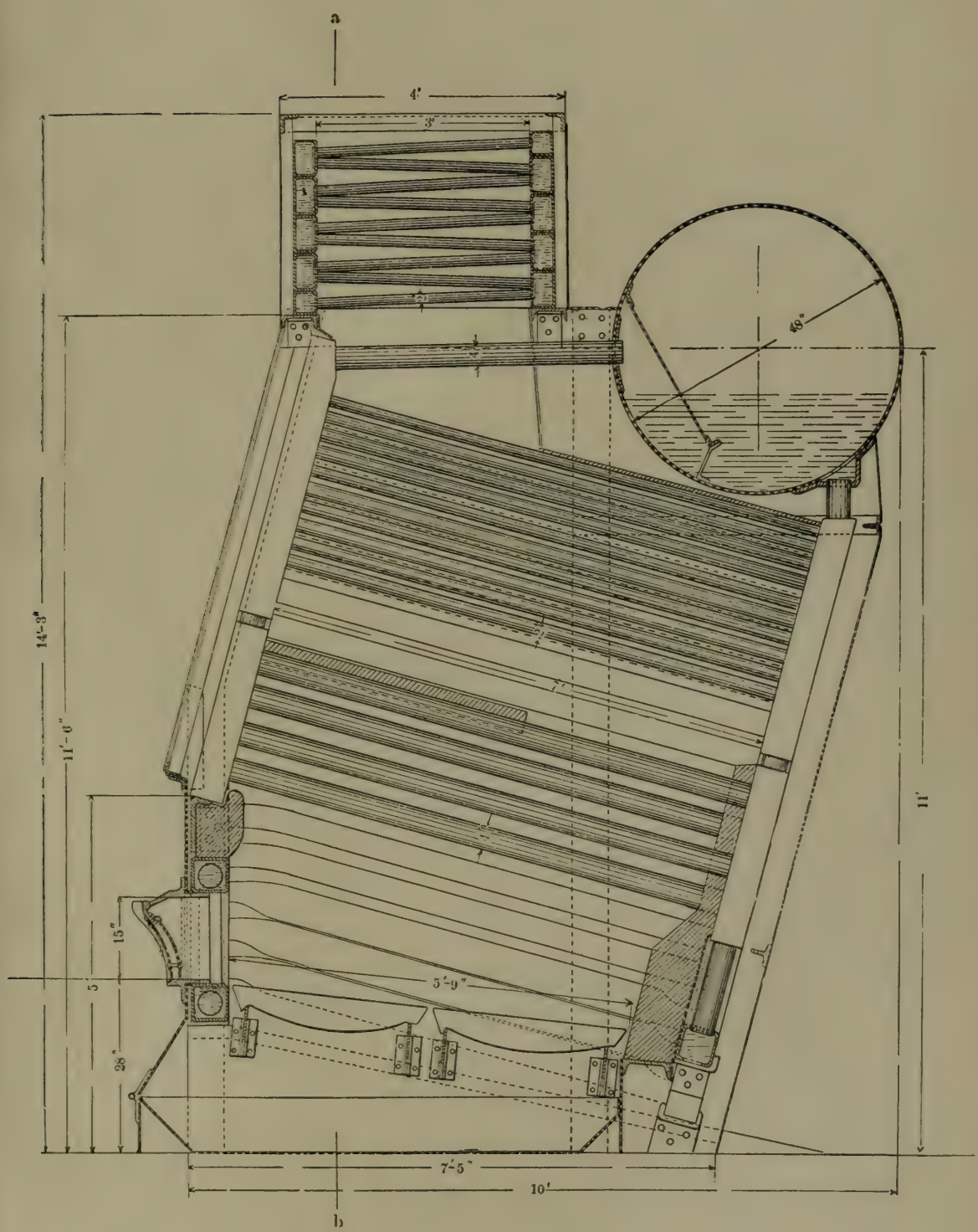


Fig. 15.—THE BABCOCK AND WILCOX BOILER.

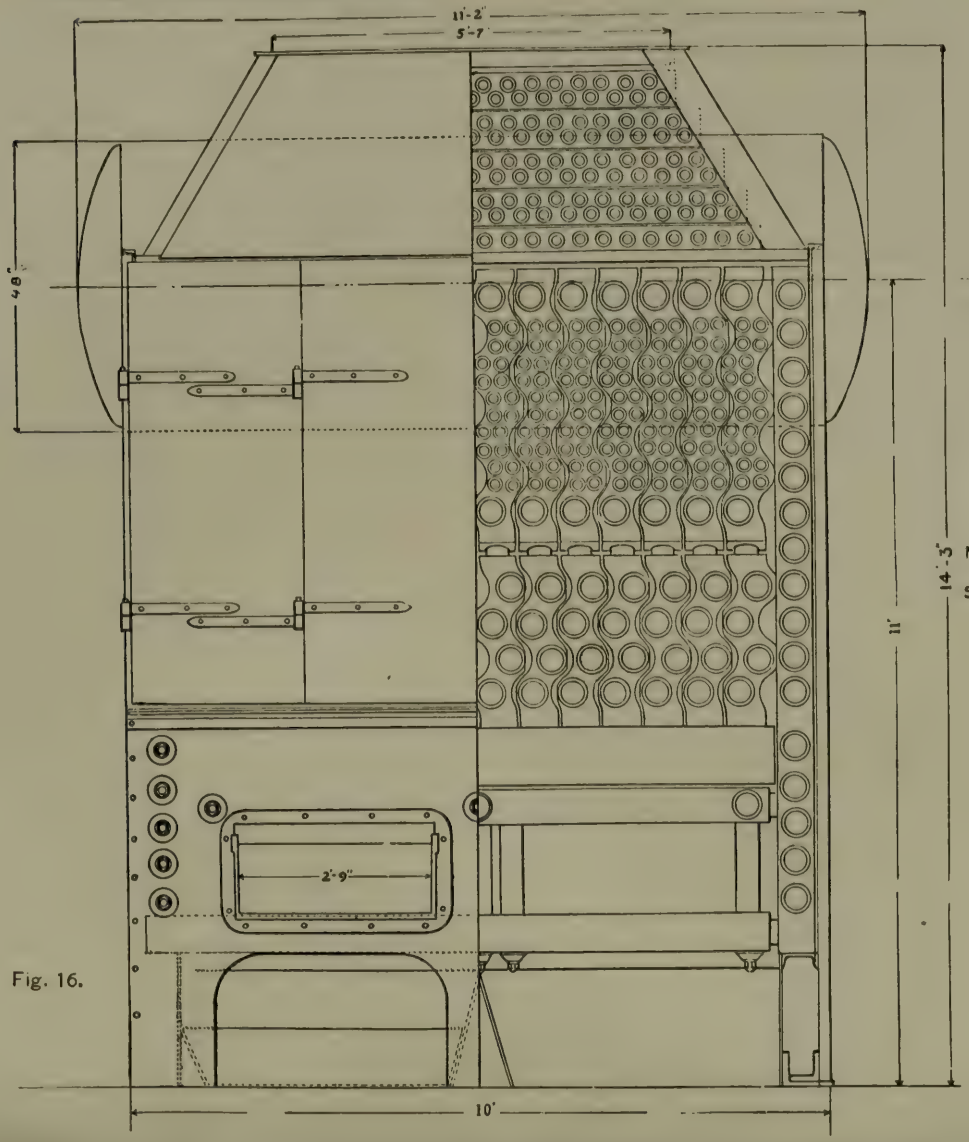


Fig. 16.

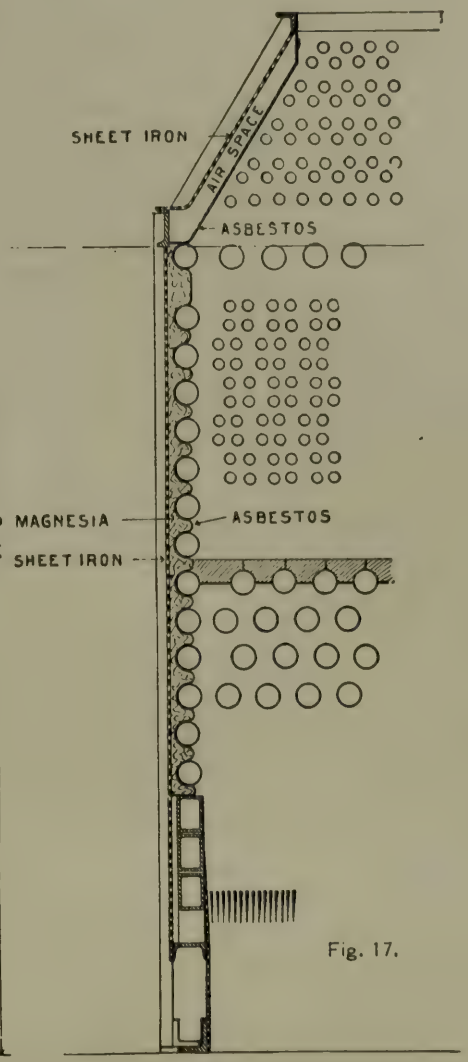


Fig. 17.

SECTION ON-az-SHEET No 11746

THE BABCOCK AND WILCOX BOILER.

During the past year Mr. T. T. Milton, chief engineer surveyor to Lloyd's Registry of Shipping, read two papers before the Institution of Naval Architects on water-tube boilers, in which he gave some particulars of a Babcock & Wilcox boiler, fitted on board the steamship *Nero*. As showing the development in the recent design, it is interesting to note that in the *Nero* the tubes above the furnace are all 1.5 inches diameter, and that instead of horizontal water walls on the sides the tubes are vertical, 3 inches diameter and about 9 feet long, spaced 5 inches from center to center, with a sheet of one-fourth inch asbestos board, backed by wrought-iron plates, outside of them. The tubes in the feed-water heater are 3 inches diameter and about 7 feet 6 inches long. The working pressure is 200 pounds.

This boiler has 2,272 square feet of heating surface and 44 square feet of grate, and is designed for 450 I. H. P. Its weight, with water and casings, is about 27 pounds per square foot of heating surface, and in steaming condition, including smoke pipe, boiler fittings, brick baffle plates, etc., 32.2 pounds.

THE BELLEVILLE BOILER.

The only water-tube boiler that has thus far been successfuly used for long periods at sea is the Belleville, which was illustrated in General Information Series No. VII, and whose construction is sufficiently familiar to render a description unnecessary. During the past four or five years the Messageries Maritimes has continued to fit them in their steamers, which run from Marseilles to Australia, and are so well satisfied with them that they have recently ordered another set of 6,000 I. H. P. for a new steamer, the *Chili*. The other steamers of this line that have them are the *Sindh*, the *Ortegal*, the *Australien*, the *Polynésien*, and the *Armand Béhic*, the last vessels of 8,000 I. H. P., on trial, though running ordinarily with 5,000 on four-fifths boiler power.

As a result of experience with the *Ortegal*, it has been found necessary in recent designs to increase the diameter as well as the thickness of the lower rows of tubes, until now they are 4.92 inches diameter and .394 inch thick. This was found necessary on account of the bending of the tubes, the curvature in some cases amounting to as much as one inch, and constantly increasing. It was also demonstrated that the boilers could not be successfully fed with salt water, except for short periods, and so a special distilling boiler is now fitted in these steamers to make up the loss of feed. The saturation is never allowed to exceed 2.5 or 3, and when the boilers are not in use they are kept full of water. After runs of three or four weeks the tubes are cleaned inside, the deposit in the upper ones being from 0.04 to 0.12 inch thick, and more in the lower rows. The zinc plates in the feed collectors and in the purifying chamber are renewed at the same time. The upper rows of tubes are found to suffer from erosion, although there is little

or no pitting of the lower tubes. The life of the tubes is from four to six years.

The automatic feed regulator, which is the bugaboo of all practical engineers, is said to work well and to be thoroughly satisfactory, regardless of the condition of the sea.

The Belleville boiler occupies more space fore and aft in a ship than double-ended cylindrical boilers do, but lesss athwartship. They are generally placed back to back along the center line with the fire rooms outboard. They are less economical than cylindrical boilers—the loss by radiation is greater, and the heating surface is not as effective—and weigh less than cylindrical boilers for natural draft working; but for forced-draft working more power can be obtained from the same weight of cylindrical boilers. They can not be forced to any extent, but inasmuch as they contain a much greater proportion of grate surface to floor space than cylindrical boilers do, it is not necessary to force them much to obtain a reasonable amount of power per square foot of floor space occupied. If a tube gives out it can be replaced without disturbing any of the elements, except the one containing the tube; but the repair takes considerable time, as the boiler must, of course, be cold before work can be done upon it. It is necessary to carry a considerable weight of spare parts, the *Ortegal* having spare sections for two whole boilers, besides spare tubes with boxes, and about 25 per cent. of all boiler fittings, including the moving parts of the feed pumps. As will be seen further on, the weight of spare parts carried by some of the naval vessels forms a considerable percentage of the weight of the boilers.

In the mercantile marine of this country Belleville boilers have recently been fitted on a large scale on board the *Northwest*, a passenger steamer of the Northern Steamship Company, running from Buffalo to Duluth, but she can not, strictly speaking, be classed amongst seagoing steamers, inasmuch as she runs in fresh water, and therefore under the most favorable conditions for the successful working of this type of boiler. It is, however, in use on a small scale in the yachts *Shearwater*, *Wild Duck*, and *Coryell*.

The boilers of the *Northwest* are 28 in number, and were designed to furnish steam at 200 pounds pressure to twin-screw quadruple-expansion engines for 7,500 I. H. P. They are divided into three groups, two of 10 and one of 8 boilers, and each group in a separate water-tight compartment. The boilers of each group are placed back to back, with fire rooms and coal bunkers outboard, and the two fire rooms of each group connected by a cross passage. The fire rooms are each 6 feet 7½ inches wide. The boilers themselves occupy a space 12 feet 9 inches wide by 112 feet long, and the athwartship passages in the fire room is 12 feet more, making the total length taken up by the boilers 124 feet. Each boiler is 8 feet wide by 11 feet high. The total grate surface is 812 square feet and the heating surface 22,736. The weight of boilers with water is 362.5 tons.

The official trials of the *Northwest* were not of such a character as to demonstrate fully the capacity of the boilers, and the details that have thus far been published have been of little value from an engineering point of view. She is now on her route, but thus far has not succeeded in reaching her designed power. Work on a duplicate vessel has been suspended pending further trials of the boiler of the *Northwest.*

The following table gives such data as are available respecting the boilers of the merchant vessels herein mentioned:

	Ortegal.	Sindh.	Australien.	Polynesien.	Armand Behic.	Northwest.	Shearwater.
Number of boilers	8	12	20	20	20	28	1
Steam pressure:							
In boilers .....pounds..	.....	170	240	240	240	250	[1] 111.5
At engines .....do...	90	90	180	180	180	200	88
Grate surface.....sq. ft..	[2] 243	295	596	633	580	812	34.17
Heating surface.....do...	6,943	11,054	23,059	23,000	23,800	22,736	804.
Tubes:							
Diameter of.....inches..	3.94	.....	4.92	4.92	4.92	.....	3.94
Thickness of .....do...	[3] .197	.....	.236–.394	.236–.394	.236–.394	.....	.....
Space occupied by boilers:							
Length .....feet..	32.67	48	70	70	70	112	8.5
Width.....do...	14	14	14	14	14	12.75	7
Height .....do...	.....	.....	.....	.....	13.33	11	11
Type of engines	Comp'd.	Comp'd.	Triple ..	Triple ..	Triple ..	Triple ..	Comp'd.
I. H. P. of engines:							
Trial	2,110	3,300	7,000	.....	8,000	.....	.....
On voyage	[4] 1,160	.....	5,000	5,000	[5] 5,000	.....	.....
Coal per square foot of grate .....pounds..	19.8	.....	.....	.....	.....	.....	12.8
Coal per I. H. P.....do...	2.7	.....	.....	.....	.....	.....	.....
Weight:							
Empty, with fittings tons	.....	149	.....	.....	.....	.....	.....
In steaming condition tons	.....	159	.....	.....	.....	362.5	.....
Including water, all mountings, and smokepipes tons	130	190	.....	.....	380	.....	.....

[1] Pressure at which test was made; boiler intended to supply steam to engine at 120 pounds.
[2] Reduced to 181.
[3] Two lower rows increased to .397 after 3½ years of service.
[4] With 7 boilers and 158 square feet of grate.
[5] With 16 boilers, or 464 square feet of grate.

The Belleville boiler has been in use in the French navy for a number of years, and some of the latest and most powerful ships are to have them. But the most noteworthy installation of them in naval vessels is in the British cruisers *Powerful* and *Terrible*, already referred to. The Russians have also used it to some extent, and are now putting it in a vessel of 14,500 I. H. P., the *Rurik II.*

The following table gives such particulars of these boilers in naval vessels as are attainable, some being from General Information Series,

No. VII, and the most of the others from the Journal of the American Society of Naval Engineers:

Name of vessel.	Number.	Steam pressure.	I. H. P.	Grate surface.	Heating surface.	Weight of boilers with water.			Width of boiler room between bunker bulkheads.	Length of fire rooms.
						Total.	Per square foot of heating surface.	Per I. H. P.		
				Sq. ft.	*Sq. ft.*	*Tons.*	*Pounds*	*Pounds.*	*Feet.*	*Feet.*
Hirondelle	10	.....	2,071	240	7,420	111.7	33.72	120.8	25.75	33.86
Voltigeur	6	.....	1,000	120	3,046	45.5	33.4	101.9	.....	.....
Cocodrile	4	.....	450	62	2,134	29	30.5	144.5	.....	.....
Rigault de Genouilly	8	.....	2,100	252	7,416	120.1	36.2	128	25.75	32.48
Actif	4	.....	400	61	1,848	27.1	32.9	152	.....	.....
Milan	12	.....	3,880	365	11,130	156.4	31.5	90.3	25.75	49.08
Alger	24	.....	7,890	753	22,265	342.6	34.46	97.3	26.58	98.95
Latouche-Tréville, Chanzy, and Charner	12	242	7,300	694	19,525	303	34.80	93.1	26.97	82.94
Leger, Levrier	4	242	2,170	210	5,630	80.3	31.95	82.9	14.51	51.60
Brennus	32	242	13,810	1,100	35,030	529.6	33.87	85.9	49.05	69.68
Descartes	16	242	8,384	700	21,503	282	29.4	75.3	.....	.....
Bouvet	32	242	13,810	1,136	32,761	400	27.3	64.9	.....	.....
Galilée	16	242	6,510	530	15,944	190	26.7	65.4	.....	.....
Powerful and Terrible	48	250	25,000	2,196	67,803	850	28.1	76.2	.....	.....
Sharpshooter	8	250	3,238	269	7,693	104	30.2	71.9	.....	.....

In addition to the vessels given in the table, the Belleville boiler is being fitted in the following vessels of the French navy: *Tréhouart*, 7,500 I. H. P.; *Bruix*, 8,800; *Bugeaud*, 9,000; *Pothnau*, 10,000; *Pascal*, 8,500, and *Catinat*, 9,000. It is fitted in six vessels of the Russian navy, the largest installation being in the imperial yacht *Standard*, of 15,000 I. H. P.

In the column of weights, those for the *Descartes*, *Galilée*, *Powerful*, *Terrible*, and *Sharpshooter*, as well as for the first six of the list, do not include spare parts, the weight of which generally amounts to from 2 to 4 per cent of the boiler weights. Nor is the weight of uptake, smoke pipes, etc., included.

Of late the tendency has been to increase the diameter of the tubes, the necessity for which has been demonstrated by experience in the merchant service. Nevertheless, where the aim is to keep down the weights, the smaller tubes are retained. Thus, the *Galilée* has 3.23-inch tubes, the *Bouvet*, the *Brennus*, and the *Sharpshooter*, 3.93-inch ones, and the *Descartes*, *Powerful*, and *Terrible*, 4.53-inch ones. The thickness of the two lower rows of tubes is almost invariably made 0.394 inch.

Within the past year Mr. Belleville has obtained a patent in this country for a circulating pipe connecting each element at the front

with the water chamber at the bottom of the same element. This is for the purpose of increasing the circulation; and a check valve is fitted at each end of it in order that the water may not go the reverse way; that is, through the circulating tube before going through the elements. Certain improvements have also been made in the method of manufacture and in the piping.

The vessels of the *Latouche-Tréville* type have not all been tried; the trial of that vessel has, thus far, not come up to expectations.

The English have made exhaustive tests of the *Sharpshooter*, both at the dock and at sea. The dock trials were for the purpose of determining whether 22.5 pounds of coal could be burned per square foot of grate with natural draft, and for determining the evaporation per pound of fuel. Each set of boilers (4 in a set) was tried separately for 12 hours, and the mean rate of combustion was 23 pounds per square foot of grate. On the evaporative test the evaporation was at the rate of 8.2 pounds per pound of coal, but the rate of combustion for this test was not given. Then followed three runs at sea, the first being of 24 hours duration, using 6 boilers, and burning less than 10 pounds of coal per square foot of grate. The results were, 14.5 knots and 1,282 I H. P. on an expenditure of 1.96 pounds of coal per I H. P.

The next two trials lasted 12 hours each, divided into two parts, and were each made with a different set of boilers. The results were:

	First set of boilers.		Second set of boilers.	
Duration of trial ..... hours.	4	8	4	8
Number of boilers in use	4	4	4	4
Coal per square foot of grate, about ..... pounds..	31	25	31	25
Steam pressure:				
In boilers ..... do....	186	182	202	170
At engines ..... do....	.....	.....	139	124
Vacuum ..... inches..	28.4	28.6	28	28.1
Revolutions of engines	206.9	185.6	180	177.4
I. H. P	1,497	1,235	1,421	1,191
Coal per I. H. P ..... pounds..	2.78	2.66	2.93	2.78
Speed of vessel ..... knots..	15.2	14	14.8	14

These were subsequently followed by others, using all the boilers, the details of which, as far as published, were:

Duration of trial ..... hours..	8	3
Number of boilers in use	8	8
Steam pressure—		
In boilers ..... pounds..	216	183
At engines ..... do....	140	143
Air pressure ..... inches..	Natural draft.	0.13
Vacuum ..... do....	27.2	26.4
Revolutions	237.9	254.8
I. H. P	2,620	3,238
Coal per I. H. P ..... pounds..	.....	2.04
Speed of ship by patent log ..... knots..	17	19

It will be noted that the coal consumption per I. H. P. per hour for the last trial is very low compared with that previously given for the trials under one-half boiler power, and at practically the same rate of combustion, about 25 pounds per square foot of grate. The short duration of the trial doubtless accounts for it. The following test of a land boiler at Nice, France, is from the Journal of the American Society of Naval Engineers, and is given on the authority of Mr. Belleville:

Duration of test		4 hrs. 5 min.
Steam pressure—		
In boiler	pounds	156.3
After passing the reducing valve	do	93.1
Draft in tube box	inch	.125
Coal burned	pounds	2,211.2
Refuse, in ashes, clinker, etc	do	227.9
Combustible consumed	do	1,983.3
Coal per hour per square foot of grate	do	12.23
Temperature of—		
Feed water	degrees F	63.5
Steam	do	361.4
Water vaporized, total	pounds	20,486
Per hour from temperature of feed at temperature of steam	do	5,020
Per square foot of grate surface	do	126.4
Per square foot of heating surface	do	3.97
Per pound of coal	do	9.62
From and at 212° F	do	5,757
Per square foot of grate surface	do	144.95
Per square foot of heating surface	do	4.55
Per pound of coal	do	11.03

The fuel was briquettes du Sud-Est (made at Port-de-Bouc), and was found from experiment to have about 92 per cent. of the thermal value of good Cardiff coal. The test was made by "judging" the condition of the fire at the beginning and end, and the evaporation is therefore higher than would have been the case if the test had commenced and ended with bare grates. There were no calorimetric measurements. The grate and heating surfaces were respectively 39.72 and 1,264.2 square feet.

The test of the boiler of the *Shearwater*, given on p. 236 of No. VII, at a slightly higher rate of combustion (12.804 pounds per square foot of grate), gave an evaporation from and at 212 degrees of 9.62 pounds per pound of coal, and 10.42 per pound of combustible, the evaporation per square foot of heating surface being 5.2 pounds per hour. This test lasted for 24 consecutive hours, beginning and ending with the fires in as near the same condition as could be judged. The moisture in the steam was 6.31 per cent.

So far as I am aware, these are the only two evaporative tests of Belleville boilers that have ever been published.

It will be observed that the ratio of heating to grate surface in the land boiler is 31.83 to 1, whereas in the boiler of the *Shearwater* it is only 23.53 to 1, which would in a measure account for the difference in evaporative efficiency.

THE THORNYCROFT BOILER.

The Thornycroft boiler, illustrated in General Information Series No. VIII, is one which has for a number of years been familiar from the success which attended its use in the Spanish torpedo boat *Ariete* in 1887. Although some of them had previously been put in small steamers, the remarkable speed made by the *Ariete* (26.003 knots on the measured mile) compared with that for a duplicate boat, the *Rayo*, fitted with a locomotive boiler (25.37 knots), at once brought it to the front as an ideal boiler for torpedo boats. From the large proportion of heating to grate surface, and the flexibility of the boiler, due to the use of bent tubes, it can stand a high degree of forcing, and is, besides, economical at ordinary rates of combustion. When the tubes are made heavy, and the boiler properly cared for, there is no reason to believe that it is not a fairly durable one; and in this connection it may be stated that the boilers of this type in the *Cushing* have been in her for five years, during which time she has, as our solitary first-class torpedo boat, necessarily been in almost constant use, laying up for two or three months during the winter for general overhauling. During this time it has been necessary to replace but one tube in the two boilers. The boilers have been fed exclusively with fresh water, and Thornycroft's instructions regarding the fitting of zinc plates in the drums have been carried out.

The *Ariete's* boilers are two in number, and each contain 37.7 square feet of grate and 2,120 of heating surface. There are eight rows of tubes, numbering 918 in all, each of 1.18 inches diameter and 0.11 inch thick. The steam drum is 26 inches diameter and 10 feet 4 inches long, and is connected to the water drums by 8-inch down-cast pipes about 5 feet long; the water drums are 14 inches in diameter. The weight of each boiler is 8 tons, and of the contained water 1.7 tons. The space occupied by it is 971 cubic feet. On trial it furnished steam at 150 pounds pressure to a compound engine for 813 horse power.

The following are some of the particulars of the boilers of the *Cushing*, which are of practically the same dimensions as those of the *Ariete*. There are 800 tubes in each boiler, the two outside rows being 1.25 inches in diameter, and the remainder 1.125 inches:

Length, fore and aft	feet	8.5
Width, extreme	do	8.58
Height, from bottom of ash pan to top of casing	do	8.5
Weight of boiler	tons	9
Weight of boiler and water to steaming level	do	11
Grate surface	square feet	38
Heating surface, external	do	2,451
Heating surface to grate surface		64.5 to 1

On her official trial the engines were not indicated, but from a test of a duplicate engine made by the builders it was estimated that the I. H. P. of each boiler was 860. The engines are of the quadruple

expansion type. The record of the official trial, the displacement being 105 tons, is given in the accompanying table, the I. H. P. and coal being estimated.

	22.5 knots.	20 knots.	15 knots.
Duration of run ..... hours	3	1	2
Steam pressure in—			
Boilers ..... pounds	245	150	110
First receiver ..... do	100	59	.....
Second receiver ..... do	40	19	.....
Third receiver ..... do	5	5	.....
Vacuum ..... inches	24	24	24
Revolutions main engines ..... per minute	370	300	210
Revolutions air pumps ..... do	122	134	100
Revolutions circulating pumps ..... do	100	100	.....
Revolutions forward blower ..... do	825	330	400
Revolutions after blower ..... do	500	436	.....
Air pressure in forward fire room ..... inches	3	.375	.5
Air pressure in after fire room ..... do	2.5	.5	.....
I. H. P. main engines	1,720	840	430
Coal per hour, bituminous ..... pounds	3,446	1,800	730
Grate surface ..... square feet	76.6	76.6	38.3
Coal per square foot of grate per hour ..... pounds	45	23	19
Coal per I. H. P., per hour ..... do	2	2.1	1.7

In 1890, an evaporative test of one of her boilers was made at the New York navy-yard by a board of naval engineers, and is thus reported in the Annual Report of the Chief of the Bureau of Steam Engineering for 1891, the weights being in pounds and the temperatures in degrees Fahrenheit.

First test, October 27, 1890, with one-half inch water pressure.

TOTAL QUANTITIES.

Duration of test ..... hours	11.43
Fuel (Pocahontas bituminous) consumed	10,526
Refuse from fuel, in dry ashes, dust, and clinkers	846
Combustible consumed	9,680
Water fed to boiler, by meter measurement, W_1	85,577.25
Per cent. of the fuel in dry refuse, etc	8.03

AVERAGE QUANTITIES.

Temperature of—	
Feed water, t_1	58.5
Steam, by thermometer	398
Uptake	536.5
Atmosphere	50.9
Fire room	78
Barometer, in inches of mercury	29.43
Pressure of steam at boiler, in pounds per square inch above a perfect vacuum, 14.7+pressure by gauge in pounds, P	264.7
Air pressure, in inches of water, at fire-room bulkhead	.5
Revolutions of blowing engines per minute	560 to 620

First test, October 27, 1890, with one-half inch water pressure—Continued.

RATES OF COMBUSTION.

	Fuel.	Combustible.
	Pounds.	*Pounds.*
Amount consumed per hour	916.66	843
Amount consumed per hour per square foot of grate surface	24.12	22.18
Amount consumed per hour per square foot of heating surface	.374	.344

VAPORIZATION IN POUNDS OF WATER.

	Per pound of fuel.	Per pound combustible.
Apparent evaporation by meter measurement, from a temperature t_1 and under a pressure P	8.13	8.84
Equivalent apparent evaporation from and at 212° and under atmospheric pressure	9.93	10.79
Actual evaporation into steam of quality Q, from a temperature t_1 and under a pressure P	7.96	8.65
Equivalent actual evaporation from and at 212° and under atmospheric pressure	9.72	10.57
Potential evaporation, or evaporation had all the heat obtained from fuel been utilized in converting the water in boiler into dry saturated steam from a temperature t_1 and under a pressure P	8.01	8.71
Equivalent potential evaporation from and at 212° and under atmospheric pressure	9.78	10.63

The percentage of moisture from ten calorimetric measurements was 2.11.

Second test, October 30, 1890, with an air pressure of 3 inches of water.

TOTAL QUANTITIES.

Duration of test ... hours	1.5
Fuel (Pocahontas bituminous) consumed	17,579.43
Refuse from fuel, in dry ashes, dust, and clinkers	1,258.8
Combustible consumed	16,320.63
Water fed to boiler, by meter measurement, W_1	132,339.92
Per cent. of the fuel in dry refuse, etc	7.16

AVERAGE QUANTITIES.

Temperature of—	
Feed water, t_1	58
Steam, by thermometer	398
Uptake	653
Atmosphere	51.3
Fire room	87.3
Barometer, in inches of mercury	29.63
Pressure of steam at boiler, in pounds per square inch above a perfect vacuum, 14.7+ pressure by gauge in pounds P	264.7
Air pressure in inches of water, at fire-room bulkhead	3
Revolutions of blowing engines per minute	990 to 1,160

Second test, October 30, 1890, with an air pressure of 3 inches of water—Coninued.

RATES OF COMBUSTION.

	Fuel.	Combustible.
	Pounds.	*Pounds.*
Amount consumed per hour	1,528.64	1,419.19
Amount consumed per hour per square foot of grate surface	40.23	37.35
Amount consumed per hour per square foot of heating surface	0.624	0.579

VAPORIZATION IN POUNDS OF WATER.

	Per pound of fuel.	Per pound of combustible.
Apparent evaporation, by meter measurement, from a temperature t_1 and under a pressure P	7.53	8.11
Equivalent apparent evaporation from and at 212° and under atmospheric pressure	9.20	9.99
Actual evaporation into steam of quality Q from a temperature t_1 and under a pressure P	7.24	7.79
Equivalent actual evaporation from and at 212° and under atmospheric pressure	8.84	9.52
Potential evaporation, or evaporation had all the heat obtained from fuel been utilized in converting the water in boiler into dry saturated steam from a temperature t_1 and under a pressure P	7.32	7.89
Equivalent potential evaporation from and at 212° and under atmospheric pressure	8.94	9.63

The percentage of moisture was 3.89.

Third test, November 4, 1890, under assisted draft, the fire room being open, but the blower running.

TOTAL QUANTITIES.

Duration of test	hours	2.5
Fuel (Pocahontas, bituminous) consumed		720
Refuse from fuel, in dry ashes, dust, and clinkers		44
Combustible consumed		676
Water fed to boiler, by tank measurement, W_1		7,593.6
Per cent of the fuel in dry refuse, etc		6.11

AVERAGE QUANTITIES.

Temperature of—	
Feed water, t_1	52
Steam, by thermometer	398
Uptake	371.5
Atmosphere	43
Fire room	90
Barometer, in inches of mercury	29.8
Pressure of steam at boiler, in pounds per square inch above a perfect vacuum, 14.7 + pressure by gauge, in pounds P	264.7
Air pressure, in inches of water, at fire-room bulkhead	0
Revolutions of blowing engines per minute	240

Third test, November 4, 1890, under assisted draft, the fire room being open, but the blower running—Continued.

RATES OF COMBUSTION.

	Fuel.	Combustible.
	Pounds.	*Pounds.*
Amount consumed per hour	288	270.4
Amount consumed per hour per square foot of grate surface	7.58	7.10
Amount consumed per hour per square foot of heating surface	.117	.110

VAPORIZATION IN POUNDS OF WATER.

	Per pound of fuel.	Per pound of combustible.
Apparent evaporation, by tank measurement, from a temperature t_1 and under a pressure P	10.55	11.23
Equivalent apparent evaporation from and at 212° and under atmospheric pressure	12.95	13.79
Actual evaporation, into steam of quality Q from a temperature t_1 and under a pressure P	9.69	10.32
Equivalent actual evaporation from and at 212° and under atmospheric pressure	11.90	12.67
Potential evaporation, or evaporation had all the heat obtained from fuel been utilized in coverting the water in boiler into dry saturated steam from a temperature t_1 and under a pressure P	9.95	10.60
Equivalent potential evaporation from and at 212° and under atmospheric pressure	12.22	13.01

The percentage of moisture was 8.09.

Fourth test, November 4, 1890, under an air pressure of 4 inches of water.

TOTAL QUANTITIES.

Duration of test ..... hours	1
Fuel (Pocahontas bituminous) consumed	2,520
Refuse from fuel, in dry ashes, dust, and clinkers	158
Combustible consumed	2,362
Water fed to boiler, by tank measurement, W_1	14,324.4
Per cent of the fuel in dry refuse, etc	6.27

AVERAGE QUANTITIES.

Temperature of—	
Feed water, t_1	52
Steam, by thermometer	398
Uptake	713.6
Atmosphere	45
Fire room	86
Barometer, in inches of mercury	29.86
Pressure of steam at boiler, in pounds per square inch above a perfect vacuum, 14.7 + pressure by gauge, in pounds P	264.7
Air pressure, in inches of water, at fire room bulkhead	4
Revolutions of blowing engines per minute	900 to 1,100

Fourth test, November 4, 1890, under an air pressure of 4 inches of water—Continued.

RATES OF COMBUSTION.

	Fuel.	Combustible.
	Pounds.	*Pounds.*
Amount consumed per hour	2,520	2,362
Amount consumed per hour per square foot of grate surface	66.32	62.16
Amount consumed per hour per square foot of heating surface	1.028	.964

VAPORIZATION IN POUNDS OF WATER.

	Per pound of fuel.	Per pound of combustible.
Apparent evaporation, by tank measurement, from a temperature t_1 and under a pressure P	5.69	6.06
Equivalent apparent evaporation from and at 212° and under atmospheric pressure	6.98	7.44
Actual evaporation into steam of quality Q from a temperature t_1 and under a pressure P	5.30	5.66
Equivalent actual evaporation from and at 212° and under atmospheric pressure	6.51	6.94
Potential evaporation, or evaporation had all the heat obtained from fuel been utilized in converting the water in boiler into dry saturated steam from a temperature t_1 and under a pressure P	5.42	5.78
Equivalent potential evaporation from and at 212° and under atmospheric pressure	6.65	7.10

The percentage of moisture was 6.68.

These tests were made with a "running start," and the condition of the fires at the beginning and end judged by the three members of the board. The fuel was Pocahontas semi-bituminous coal, containing 80 per cent of fixed carbon and 3.7 per cent of ash. The firemen were taken from the receiving ship *Vermont*, at the New York navy-yard, and had had no previous experience in firing this type of boiler, and the board expressed the opinion that with better firing better results would have been obtained.

Subsequently, three trials, each of one hour's duration, were made in the Potomac river by a board of naval engineers for the purpose of getting the I. H. P. of the engines under the several conditions of the trials. The results, published in the annual report of the chief of the Bureau of Steam Engineering, are given below. The displacement of the boat at the beginning of the first hour was 130 tons, and at the beginning of the fourth hour 125.

PERFORMANCE.

	Average for hours.			
	A.	B.	C.	D.
Steam pressure at boiler per guage.....pounds..	84	116.5	191.9	222.5
Steam pressures, H. P. steam chest, per guage.....do....	65	98.8	173.3	218.8
Steam pressures, absolute:				
First receiver.....do....	34.5	51.3	91	110
Second receiver.....do....	13.9	22	43.3	51.5
Third receiver.....do....	7.4	10.1	17.1	20.8
Vacuum in inches.....	25.3	24.1	23	19.9
Revolutions per minute:				
Starboard engine.....	205.9	240.1	298.8	328.3
Port engine.....	199.3	234.2	285.4	.....
Starboard air and feed pump engine.....	291	199	611	237
Port air and feed pump engine.....	319	554	429	545
Circulating pump engine.....	320	460	543	420
Forward-blower engine.....	.....	.....	776	912
After-blower engine.....	498	797	717	993
Temperature:				
Engine room.....	96	103	104	107
Fire room.....	139	130	143	125
Injection water.....	81	80	82	79
Feed water.....	88	104	126	149
Air pressure in inches of water:				
Forward fire room.....	.....	.....	1.06	2
After fire room.....	.4	1.7	1.2	2.1
Grate surface in use.....square feet..	38.3	38.3	76.6	76.6
Mean pressure in starboard H. P. cylinder:				
Top.....pounds..	27.24	39.2	60.15	67.45
Bottom.....do....	29.92	42.29	61.43	67.74
Mean pressure, starboard, first I. P. cylinder:				
Top.....do....	10.22	13.88	22.95	32.73
Bottom.....do....	9.4	13.01	19.45	29.56
Mean pressure, starboard, second I. P. cylinder:				
Top.....do....	5.5	8	13.32	15.09
Bottom.....do....	5.15	7.73	13.32	15.9
Mean pressure, starboard, first L. P. cylinder:				
Top.....do....	2.18	3.74	7.88	9.6
Bottom.....do....	1.96	3.26	6.31	8.43
Mean pressure, starboard, second L. P. cylinder:				
Top.....	1.68	3	6.13	7.29
Bottom.....	2.06	3.11	6.2	7.79
I. H. P.:				
Starboard H. P. cylinder.....	43.61	72.51	134.66	164.59
Starboard first I. P. cylinder.....	30.63	48.92	96.08	154.98
Starboard second I. P. cylinder.....	32.87	56.59	119.25	153.61
Starboard first L. P. cylinder.....	12.75	25.18	63.67	88.77
Starboard second L. P. cylinder.....	11.55	22	55.48	74.35
Total power, starboard engine.....	131.41	225.2	469.14	636.3
Total power, port engine.....	129.89	224.32	457.4	636.3
Total power, both main engines.....	261.3	449.52	926.54	1,272.6
Total power, both main engines, air and feed pumps...	277.2	469.22	953.84	1,292.1
Total power, main and auxiliary engines.....	286.1	484.02	971.24	1,336.2
Speed, by observation, in knots per hour.....	13.08	13.4	15.42	17.5

Estimated maximum I. P. H. of auxiliary machinery in use during trial.

Starboard air and feed pump engine	7.6	5.2	16	6.2
Port air and feed pump engine	8.3	14.5	11.3	14.3
Circulating pump engine	4.5	4.5	4.5	4.5
Forward blower engine	.....	.....	5.8	12.9
After blower engine	3.4	9.6	6.1	14.7
Steering engine	1	1	1	1
Total auxiliary horse power	24.8	34.8	44.7	53.6
Square feet cooling surface per collective horse power	3.68	2.17	1.08	0.79
I. H. P., collective, per square foot grate surface	7.47	12.64	12.68	17.44
I. H. P., main engines, air and feed pumps, per square foot of grate surface	7.24	12.25	12.45	16.87

NOTE.—Owing to lack of opportunity, the indicators used on the *Cushing's* trial were not standardized, and consequently there is a probable error in the horse powers given of from 3 to 10 per cent. Experience with several other vessels where the indicators were standardized has shown that it would probably be fair to allow a reduction of 5 per cent from the horse powers as recorded.

In November, 1888, Prof. Kennedy made five tests of one of the Thornycroft boilers fitted on torpedo boat *No. 258*, two with natural draft, and three with forced draft at different pressures. The boiler had 30 square feet of grate and 1,837 of heating surface. The tests were each made with a running start, and the condition of the fire "judged" to be the same at the beginning and end of the test.

The test was conducted by running the engine, taking indicator cards, measuring feed water and coal. The engine was triple-expansion, with cylinders 14, 20, and 31.5 inches diameter by 16 inches stroke; the piston rods 2.25 inches diameter; all cylinders jacketed. The fuel had a calorific value of 14,900 thermal units.

The results of these tests are given in the table, which is taken from the minutes of proceedings of the Institution of Civil Engineers, England. In the discussion which followed the reading of this paper it was pointed out that the duration of the tests, especially the one at natural draft with the low rate of combustion, was so short as to render the results unreliable; and that inasmuch as the ashes were thrown on the fire at the end of the test, the real rate of evaporation was necessarily lower than shown by the figures. Furthermore, calorimetric measurements were not made, and consequently nothing is known of the amount of moisture present with the steam.

The weight of the boiler with all fittings, feed pump, spare gear, and smoke pipe was 11.3 tons, and the maximum I. H. P. developed by the main engines 770. The auxiliary engines in use were the feed pump, fan engine, circulating engine, and steering engine.

Trials.	1.	2	3.	4.
Duration ..... hours and minutes..	4 57	5 9	4 0	2 0
Atmospheric pressure ..... pounds..	14.55	14.80	14.84	14.45
Steam pressure in boiler ..... do..	181.8	171.2	149.4	180.5
Steam pressure in H. P. valve chest ..... do..	22.7	79.2	120.7	168.4
Air pressure ..... inches..	.....	.27	.49	2
Weight of coal ..... pounds..	1,006.5	2,877	3,575	3,503
Weight of ashes ..... do....	233.5	197	.....	192
Weight put back on fire ..... do....	233.5	170	.....	192
Coal burned per hour ..... do....	203.3	559	894	1,751
Grate surface ..... square feet..	26.2	30	30	26.2
Heating surface ..... do....	1,837	1,837	1,837	1,837
Coal per square foot of grate per hour ..... pounds..	7.74	18.6	29.8	66.8
Feed water per hour ..... do....	2.281	5,852	8,583	15,554
Temperature of feed, F	76.3	78	83.8	111.2
Temperature of steam	380.2	375.5	365.5	379.6
Evaporation from and at 212° (with ashes burned)	13.4	12.48	12	10.29
Temperature of smoke pipe gases	421	540	610	777
Air pressure in smoke pipes	0	.03	.12	.40

Thus far the boilers had been worked singly, that is, with a separate steam pipe connecting each boiler with its engine. But in 1891, the Danish Government, which had had some experience with the Thornycroft boiler in torpedo boats, determined to fit them "in battery" on board the third-class cruiser *Geiser*, of about 1,300 tons displacement. An order was accordingly given to the Thornycroft Company for a design of eight boilers of 3,000 indicated horse power, and the boilers were built at Copenhagen. They are arranged in two groups of four each, each group in a separate water-tight compartment, and the boilers of each group placed back to back, making four fire rooms for the eight boilers. The total grate surface is 171 square feet and the heating surface 12,000. On trial they supplied steam to twin-screw triple-expansion engines for 3,157 I. H. P. The inner and outer rows of tubes in these boilers are of steel, and the intermediate ones of brass.

The trials of this vessel took place in the autumn of 1892, and the principal results are given in the table on the following page, which is from Engineering.

The temperatures referred to were measured by means of graphite pyrometers, one at the base of each smoke pipe, and one between the boiler tubes on one side of each boiler.

The report of the Danish director of naval construction, Capt. Neilsen, states:

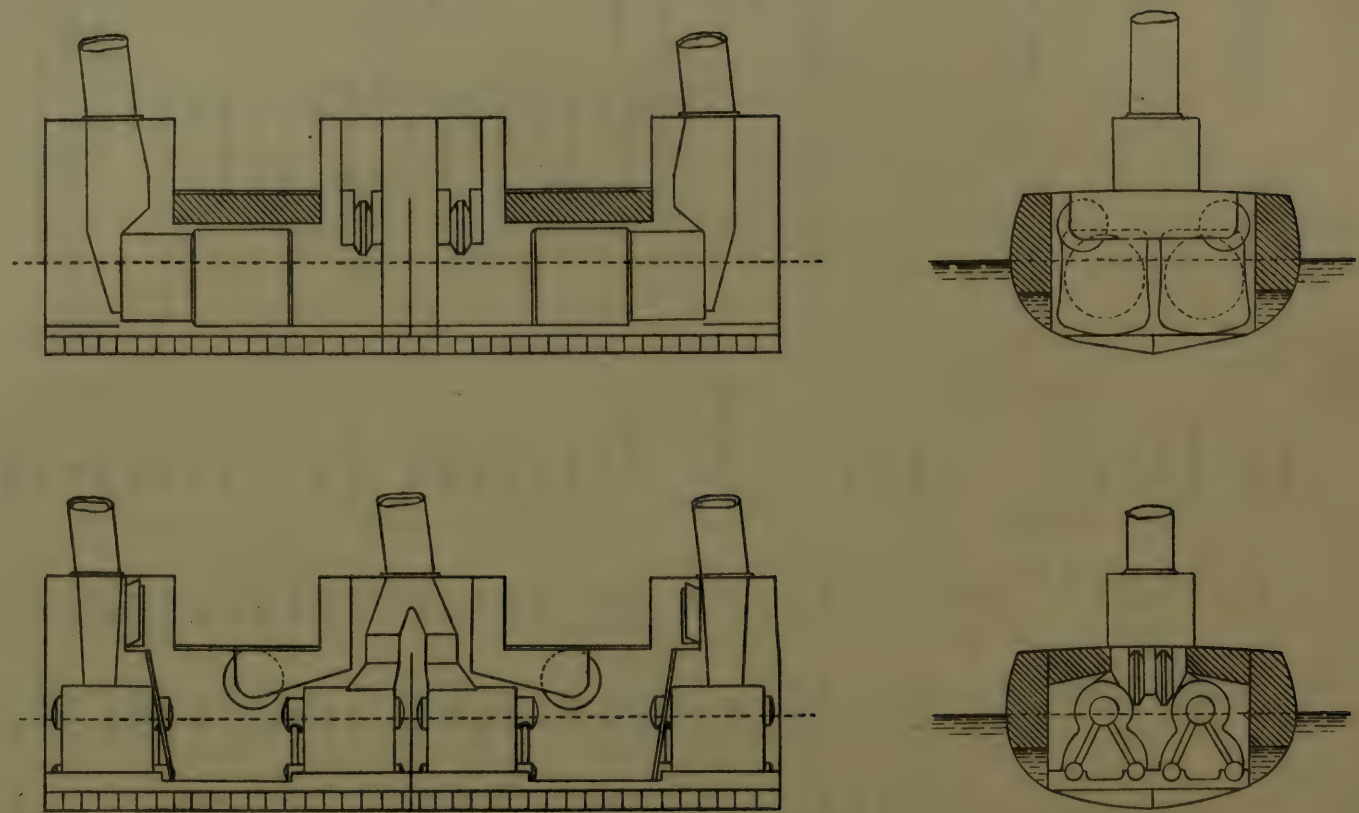
During the trials the boilers worked most excellently; steam was kept up with the greatest ease. The steam-generating power could be regulated nearly immediately to suit the steam consumption of the engines by means of the stop valves on the steam pipes of the fans. At the end of the sea-speed trials we forced the engines up to 3,314 I. H. P. in a few moments, after having steamed over seven and one-half hours, with an air pressure of about 0.6 inch, and could keep the steamer at this high horse power with an air pressure of about 1 inch. When going full speed we often

stopped the ship immediately, and we could bring the ship up to full speed in a few minutes, it being not necessary to pay any regard whatever to the boilers, these being able to stand all sudden changes of temperature. The boilers did not prime either during the highest forcing or during sudden changes in the working of the engines.

		Coal-consumption trial.	Sea-speed trial.	Full-power trial.
Date of trial		Oct. 27	Nov. 2	Nov. 5
Duration of trial	hours	6	8	4
Displacement of ship on trial	tons	1,265	1,259	1,276
Steam pressure in—				
Boilers	pounds	167	176	177.6
H. P. valve chest	do	146.6	164.9	164
First receiver	do	56.6	70	75
Second receiver	do	5.4	9.5	13
Vacuum	inches	26.5	25.3	25.1
Air pressure (inches of water)		(1)	.57	.81
Revolutions of fans per minute		.....	475	571
Ratio of cut-off		.48	.54	.68
Mean pressure in—				
H. P. cylinders	pounds	33.6	46.4	52.2
I. P. cylinders	do	24.7	30.8	36.4
L. P. cylinders	do	10	12	14.6
Mean revolutions per minute of main engines		204.7	227.9	250.6
Collective I. H. P		1,744	2,422	3,157
Mean temperature in—				
Forward smoke pipe	degrees F	423	466	585
After smoke pipe	do	439	482	628
Mean temperature between boiler tubes:				
Fire room I (foremost) — Starboard	degrees F	664	882	970
Fire room I (foremost) — Port	do	727	896	1,078
Fire room II — Starboard	do	752	934	963
Fire room II — Port	do	682	851	970
Fire room III — Starboard	do	639	815	876
Fire room III — Port	do	670	828	901
Fire room IV (after) — Starboard	do	631	804	932
Fire room IV (after) — Port	do	729	919	1,004
Total coal consumption on trial:				
Fire room I — Starboard	pounds	2,260	4,850	3,160
Fire room I — Port	do	2,160	4,900	3,160
Fire room II — Starboard	do	2,360	4,390	3,020
Fire room II — Port	do	2,340	4,010	2,810
Fire room III — Starboard	do	2,320	4,170	2,780
Fire room III — Port	do	2,210	4,040	2,760
Fire room IV — Starboard	do	2,310	3,940	2,900
Fire room IV — Port	do	2,310	4,270	2,990
Coal consumption per hour in all boilers	do	3,045	4,309	5,895
Coal consumption per hour per indicated horse power	do	1.75	1.77	1.87
Coal consumption per square foot grate area	do	17.8	25.2	34.5
Speed of ship	knots	14.34	16	17.1

[1] Natural draft.

Diagram Showing Space Occupied by Locomotive & Thornycroft Water-Tube Boilers in Vessels of the "Speedy" Type.



The official report says:

Another great advantage which the boiler possesses is its small weight as compared with ordinary boilers. This can best be seen by comparing the weight of the boilers in the *Geiser* with the weight of the boilers in the cruiser *Hekla*. This cruiser has exactly the same engines as the *Geiser*, and its six low cylindrical boilers are proportioned to the same horse power (3,000 I. H. P.) as the *Geiser*, both ships being of the same type and displacement.

	Hekla.	*Geiser.*
	Tons.	*Tons.*
Boilers with pipes, feed pumps, uptakes, smoke pipes, and all other fittings in the boiler rooms	120.2	90.8
Water in boilers	48	17.4
Total	168.2	108.2

Thus 60 tons, or over one-third of the total weight of the boilers in the *Hekla*, are saved in the *Geiser*.

At the recent meeting of the Institution of Naval Architects Mr. Thornycroft stated that the Danish authorities were so well pleased with the results in the *Geiser* that they intended putting similar boilers in the armored coast-defense vessel *Skiold*, of 2,150 tons displacement and 2,200 I. H. P.

The water of the Baltic being so nearly fresh, the objections to water-tube boilers for seagoing vessels do not apply, and good results should therefore be expected from the boilers in these ships.

The success of this group of boilers in the *Geiser* led Mr. Thornycroft to make an offer to the British Admiralty to supply one of the torpedo vessels then building with boilers of this type, guaranteeing to furnish 4,500 I. H. P. instead of 3,500 as required with locomotive boilers, and to do it on less weight of boilers and without occupying any more space. The arrangement of boilers in the two cases is shown in the accompanying illustration, which is from Mr. Thornycroft's paper, as are also the following particulars of the boilers:

Particulars of locomotive and Thornycroft boilers in vessels of the "Speedy" type.

	Locomotive boilers.	Thornycroft water-tube boilers.
Total indicated horse power	3,500	4,500
Number of boilers, per ship	4	8
Area of grate, per boiler ... square feet	45.5	25.5
Total area of grate, per ship ... do	182	204
Heating surface, per boiler, of fire box ... do	272¾	64.6
Total heating surface, per boiler ... do	1,597	1,840
Total heating surface, per ship ... do	6,383	14,720
Total weight of boilers and mountings, dry ... tons	82	71.52
Total weight of water in boilers ... do	30	12.78
Total weight of boilers and water, per ship ... do	112	84.30

The trials of the *Speedy* took place during the latter part of 1893, and consisted of one of eight hours' duration with one-half inch air pressure, and another of three hours, for full power. The results in each case were:

Duration of trial.....hours..	8	3
Steam pressure.....pounds..	183	194
Air pressure.....inches..	0.58	1.7
I. H. P	3,043	4,675

The engines of the *Speedy* are of the same size as those of the other vessels of her class; cylinders, 22, 34 and 51 inches diameter by 21 inches stroke.

Of this trial Mr. Thornycroft says:

When working at the highest power attained the boilers were only forced to a very limited extent, the mean air pressure being 1.7 inches, and, even with this air pressure, had the navy stokers had more practice with the particular form of grates, a higher result could have been obtained. The only point which presented any difficulty in these trials was that of feeding the boilers with sufficient regularity. The *Speedy* has two Weir pumps, which are arranged to deliver into a main feed pipe common to all the boilers, in which the water was in excess of the boiler pressure by some 50 pounds. On each boiler there was a check valve, by which the feed was controlled. This system, which is perfectly efficient for boilers holding large volumes of water, seems to require some modification in the case of water-tube boilers, where the water contained is relatively very small for the rate of evaporation, and I have come to the conclusion that some form of automatic control is desirable. In the Belleville boiler this has already been adopted with success. With the view to lengthen the life of the tubes, they were galvanized both inside and out. The zinc on the outside is, I consider, more useful than the inner coating, which, being exposed to impure water at a high temperature, soon disappears and is, therefore, only a temporary protection.

In opening up boilers and steam pipes we have frequently experienced the presence of explosive gases in a most unpleasant manner. It seems to me possible that the very large surface of zinc must be the cause of the generation of these gases. This theory is supported by the fact that we have only had this experience since the tubes have been galvanized, and also by the disappearance of the zinc.

I have made experiments which proved that working with water entirely free from oil—very severe working (20 pounds of water per square foot of heating surface,)—the tubes could not be overheated; but the addition of a small quantity of the greasy deposit taken from a boiler working with condensing engines was sufficient to cause the destruction of the tubes by overheating without any increase in the rate of working. I further experimented with grease taken from the inside of a boiler to ascertain the temperature of its evaporation, and found that this was so high that when heated on a piece of brass tube it continued to give off vapor after the critical temperature at which brass loses most of its tenacity had been arrived at. From this experiment the effect of a coating of this deposit can be easily surmised. Under the rapid transmission of heat, gas would continue to be liberated from the surface, which would increase in temperature, owing to the non-conducting power of the film of gas which necessarily precludes the contact of water with the tube surface, the water being only enabled to preserve the tubes because its boiling point is lower than that of grease. Consideration of these facts seems to me to prove that for a high rate of working in boilers where grease may be present in the feed water brass tubes are quite unsuitable; copper may, perhaps, be used, as the temperature at which its

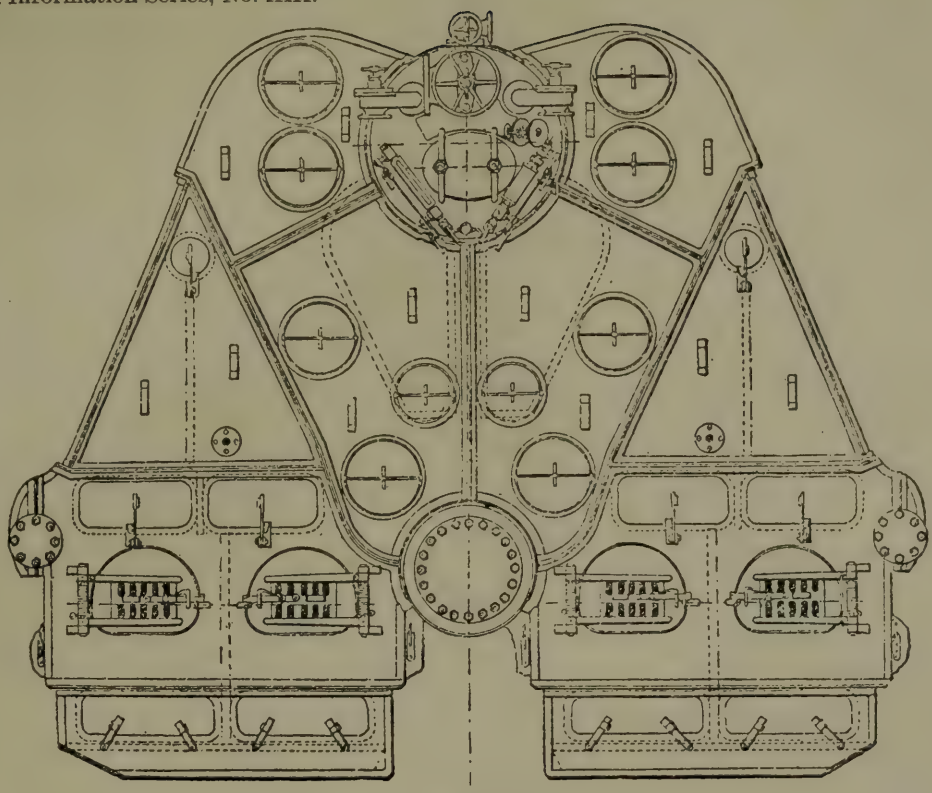


Fig. 18.

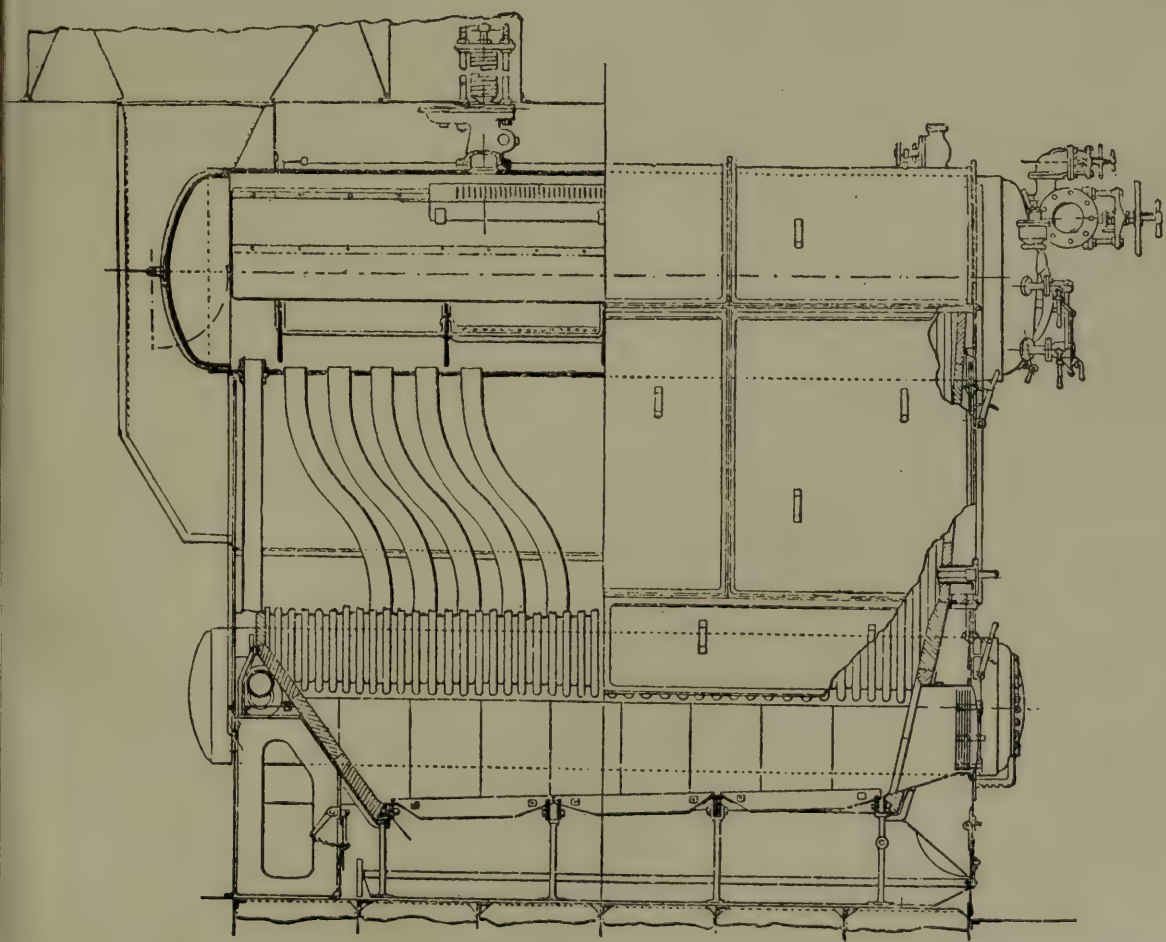


Fig 19.

THE THORNYCROFT BOILER—DARING TYPE.

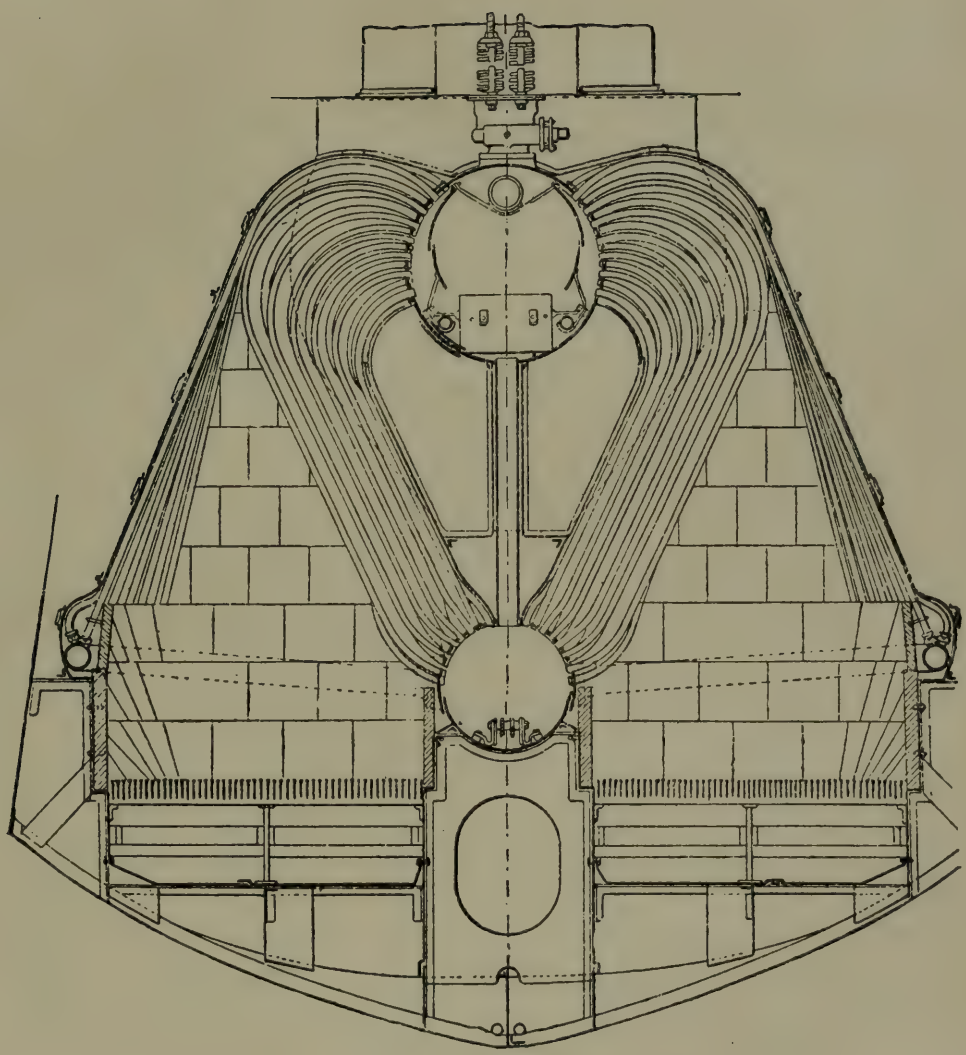


Fig. 20.

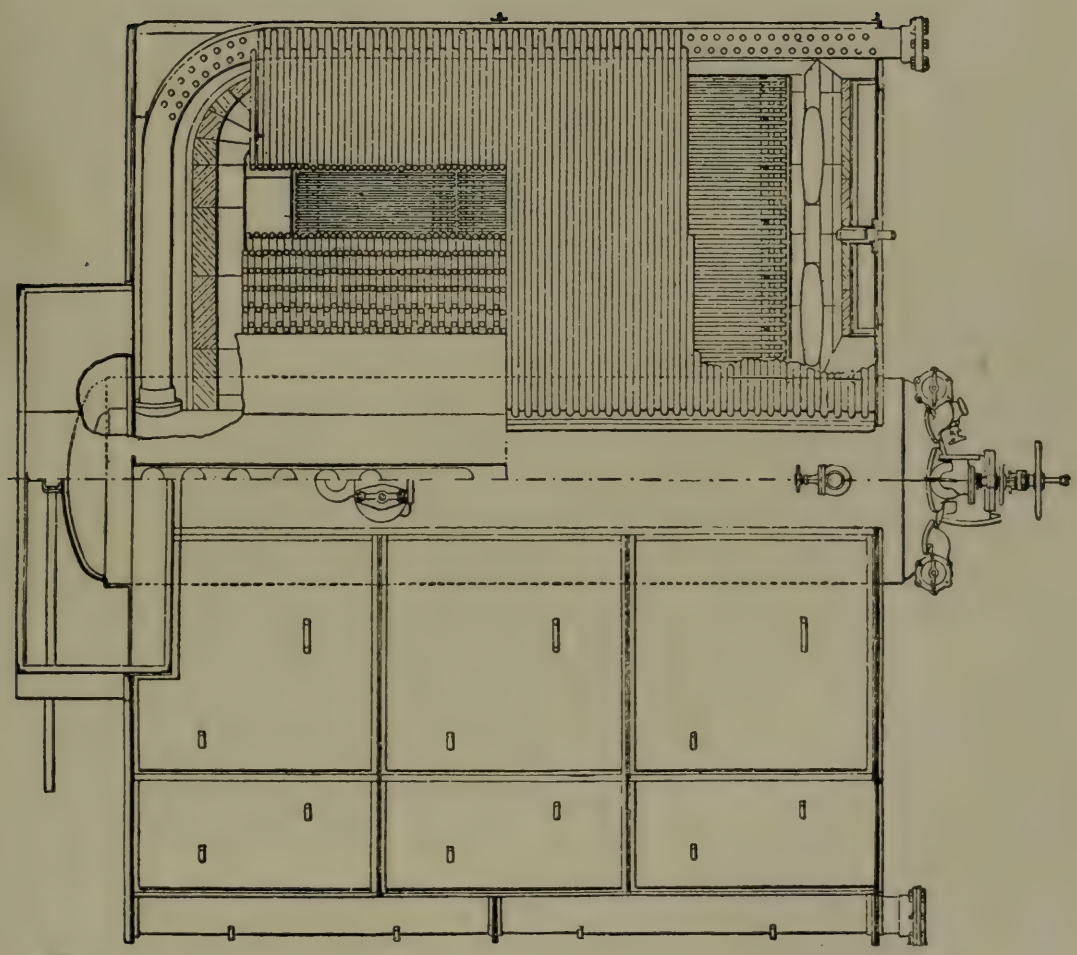


Fig. 21.

tenacity is greatly reduced is much higher. M. Du Temple found that copper tubes lose their strength in time, but the relatively small diameter of his tubes to their length seems to be an element which might cause this trouble, and a further unfavorable condition is the immersion of their upper ends.

I have recently made experiments on the relative circulation of boilers when the generating tubes deliver above the water in the separator and below it, and I have found that, in the case where they deliver above, the circulation is rather more than double when they deliver below. The method of measurement I adopted was to put a rectangular notch, similar to those usually employed in gauging small streams, across the separator, so that all the water that went down the downtakes had to pass over it, and then observed the flow over the notch through a glass window in the end of a boiler, and thus, knowing the size of the stream, was able to calculate the circulation. I found that, in the case of the above-water delivery, the circulation was 105 times the feed; that is to say, for every pound of steam brought up by the generating tubes, 105 pounds of water are also passed through them. The boiler experimented upon with the drowned tubes was similar, as far as possible, to the other, which was of my usual construction, so that the reduction in circulation can only be attributed to the upper ends of the tubes being immersed.

Mr. Thornycroft has recently invented another type of water-tube boiler which he terms the *Daring* boiler, from the fact that H. M. S. *Daring* is the first vessel in which it has been fitted.

It will be seen from figs. 18 to 21 that it differs materially from the old type with which we have become familiar, the first thing that strikes one being the absence of the external circulation pipes connecting the upper, or steam drum, with the water drums; and the next the substitution of one central for the two wing water drums, practically making the boiler a two-furnace one and simplifying the curvature of the tubes connecting the water with the steam drum. The sides are formed of two staggered rows of tubes connecting with the steam drum at the top and with a pipe on either side, which is connected with the water drum at the rear, as shown in fig. 21, and protected from the heat of the furnace by fire brick, as shown in figs. 19, 20, and 21. These tubes are expanded into the upper drum and fastened to the lower pipes by union joints protected from the heat of the furnace as shown. The circulating tubes are the central curved ones connecting the upper and lower drums, figs. 19 and 20, and occupying the heart-shaped space between the two nests of tubes. The gases are supposed to pass through the triangular spaces between the tubes at the top and bottom, and thence into the heart-shaped passage and to the uptake at the end of the boiler. The difference in temperature between the gases in this chamber and amongst the tubes is deemed sufficient to insure ample circulation. The tubes are curved to allow for difference in expansion.

The special advantages claimed for this boiler over the old are (1) that it occupies less space in the vessel, due to the absence of the outside downcast pipes; (2) it is lighter on account of the smaller quantity of water which it contains due to the fitting of only one drum; (3) it practically divides the furnace into two parts, and makes it possible to build a boiler of larger power than was possible with the old one; (4) each furnace has considerable height, making it easy to fire and pro-

viding good combustion of the gases; (5) it is well adapted to being grouped; (6) it accommodates itself readily to any shape of hull.

When used in battery, Mr. Thornycroft's idea is to omit the outside rows of tubes in all except the end boilers. He says:

As each fire is common to two boilers, one boiler can not be put out of action without another boiler losing half its fire, but this boiler would still do half duty, as half its surface would be in no way affected.

The *Daring* has three of these boilers intended to work at 210 pounds pressure and to furnish steam to triple-expansion engines for 3,500 I. H. P. They have 189 square feet of grate and 8,892 of heating surface, and during her recent official trial furnished steam to twin-screw triple-expansion engines for 4,735 I. H. P. during one of her runs on the mile, the steam pressure at the time being 208 pounds and the air pressure equal to 3.15 inches of water.

THE YARROW BOILER.

A type of this boiler was illustrated on p. 112, No. IX, since which time little or no change has been made in it except to omit the outside circulating pipes connecting the steam and water drum with the lower water chambers. The illustration is so clear as to render a detailed explanation unnecessary, and it only remains to remark that the circulation is supposed to be down the outside rows of tubes and up the others. (See figs. 22 and 23.)

The most notable installation of this boiler is on board the British first-class torpedo boat *Hornet*, where eight of them, weighing 43 tons, supplied steam to triple-expansion engines for about 4,300 I. H. P., enabling this boat of 215 tons displacement to make a continuous run of 3 hours' duration at a mean rate of 27.628 knots; while a sister vessel, the *Havock*, also built by Yarrow and fitted with locomotive boilers, made only 26.125 knots on 3,500 I. H. P. and 54 tons of boilers. The measured mile trials of the *Hornet* gave 27.313 knots and those of the *Havock* 26.783. (See pp. 31–41.)

These boilers are built with straight copper tubes 1 inch in diameter, and Mr. Yarrow states that a defective tube was on one occasion cut out and replaced in 40 minutes.

The eight boilers of the *Hornet* contain 165 square feet of grate and 8,216 of heating surface, the grates being 6 feet 6 inches, and the steam drums about 7 feet 6 inches long. Before placing them in the vessel one of them was subjected to an evaporative test of short duration, during which it evaporated at the rate of 12,500 pounds per hour from water of 60° into steam at 180 pounds pressure.

Of the construction and working of this type of boiler, Mr. Yarrow, at the last meeting of the Institution of Naval Architects, said:

Although his firm had built a large number of water-tube boilers during the last seven years with straight tubes, it might be of interest to the meeting to know that they had never had a single leakage between the tube and tube plate. This fact

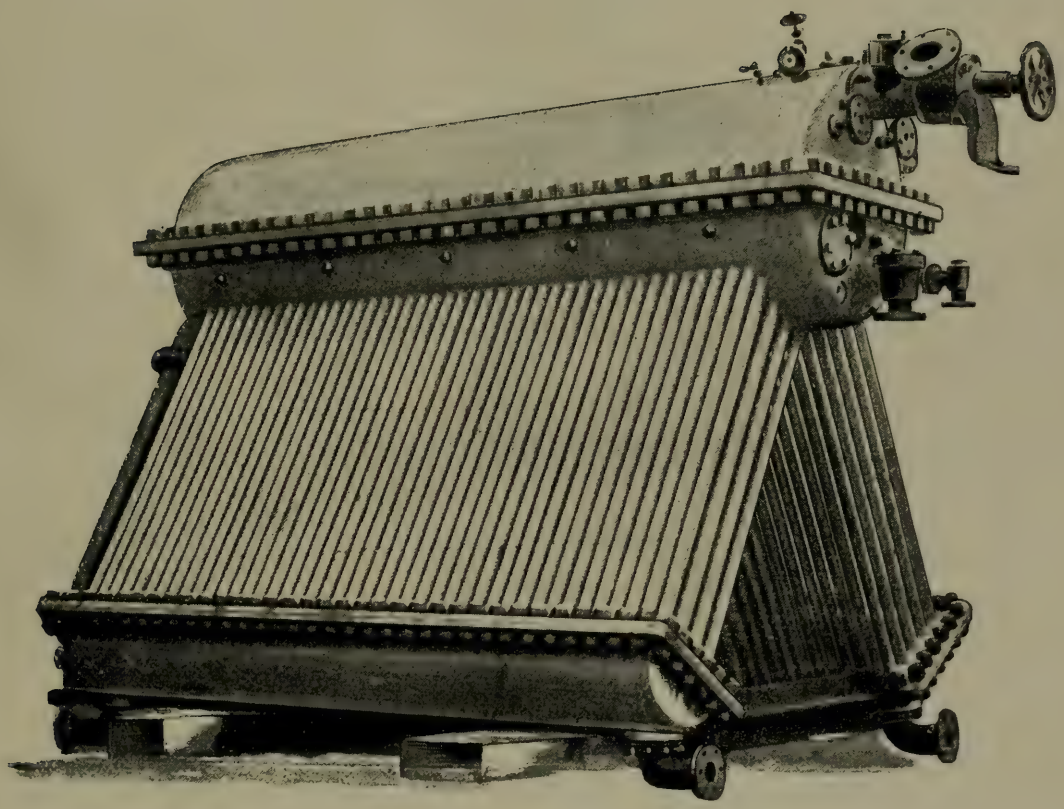


Fig. 22.—THE YARROW BOILER.

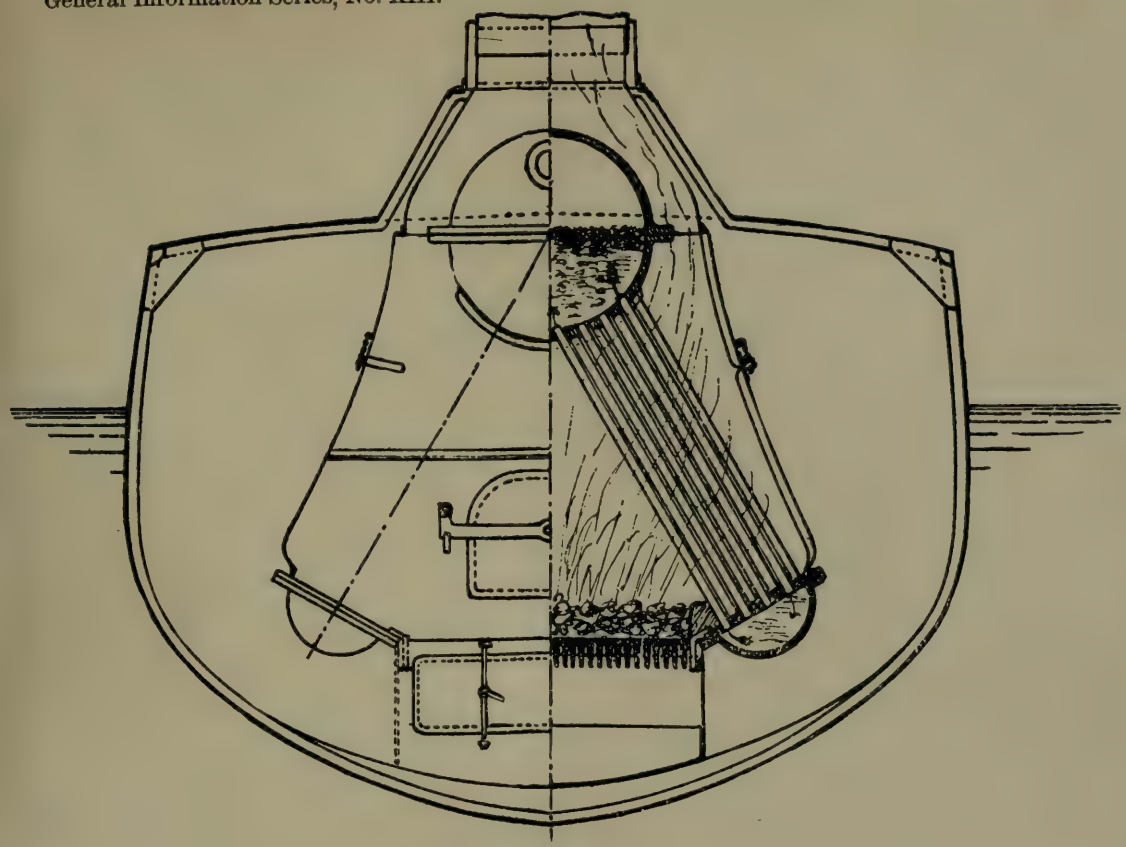
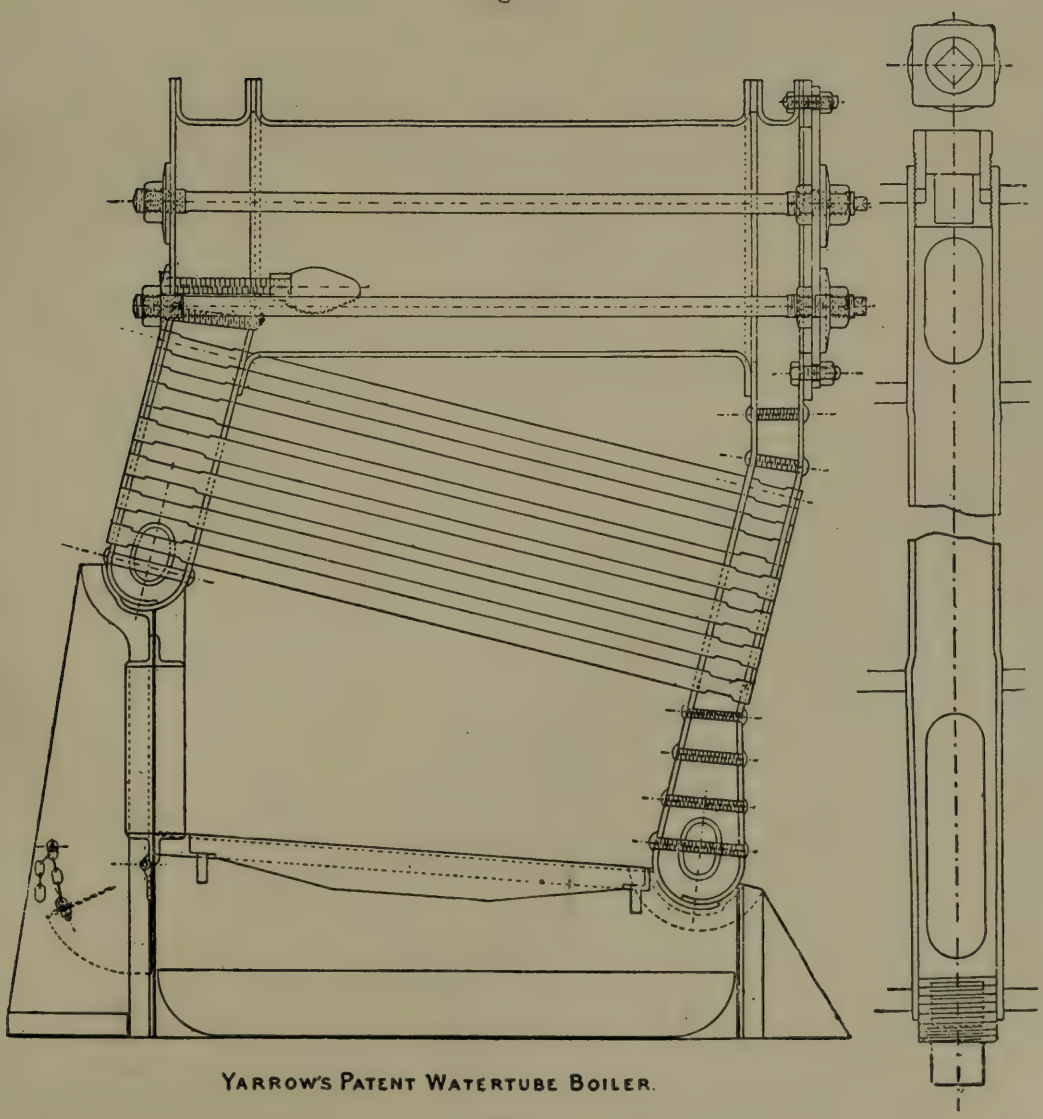


Fig. 23.



YARROW'S PATENT WATERTUBE BOILER.

Fig. 24.

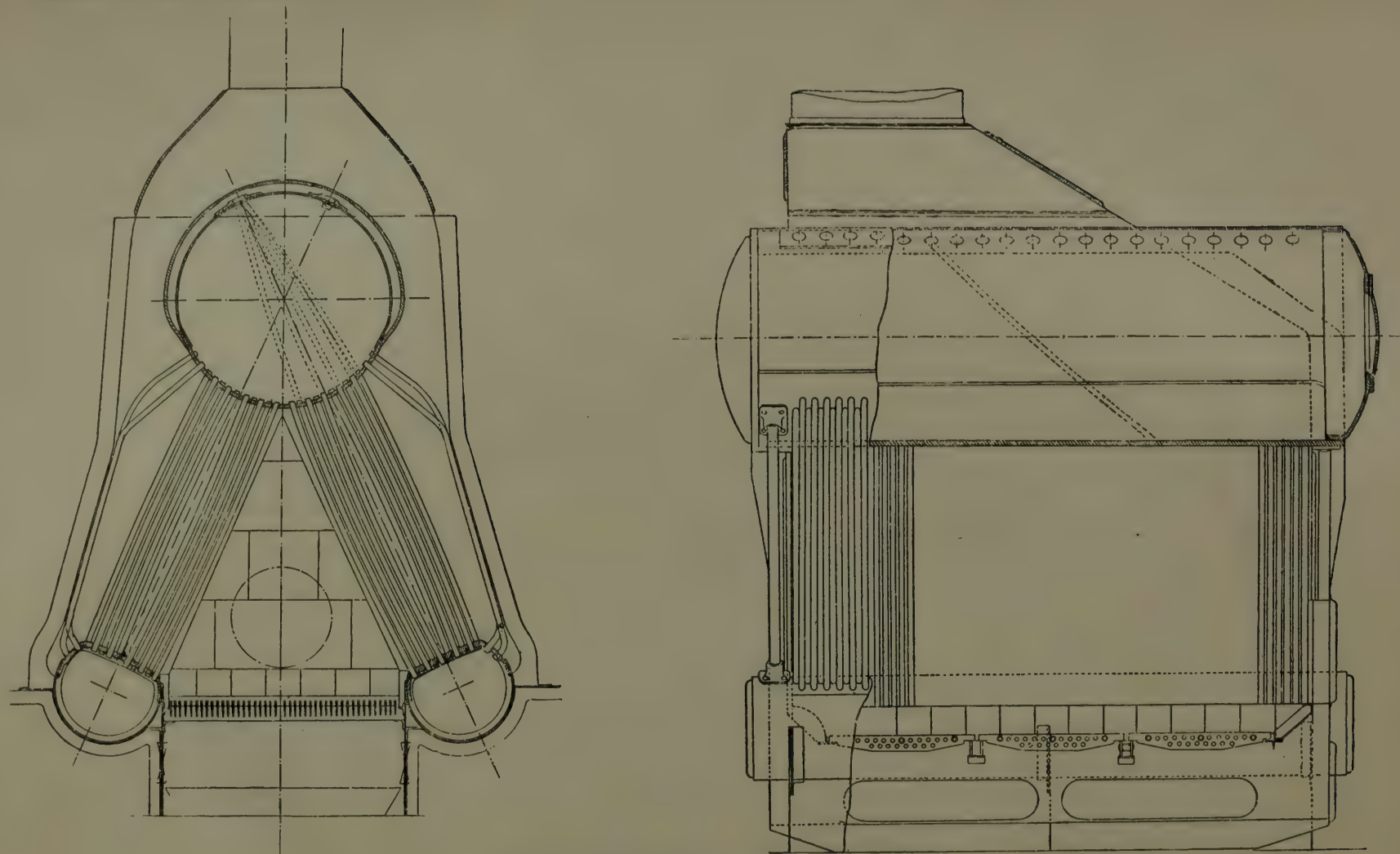


Fig. 25.—BLECHYNDEN'S WATER-TUBE-BOILER.

proved, they believed, that there was nothing objectionable in the straight tube system, whilst it clearly offered many advantages, both in construction and in service. Experience had shown that steel tubes, whether galvanized or not, rapidly deteriorated, and if the tubes were galvanized on the inside a rough surface was caused, which, in some instances, retarded the circulation of the water. There was also the possibility of portions of spelter lodging in the tubes and partially blocking up the passage, or causing such an obstruction which would allow sediment to collect. So far as his experience went, it led to the conclusion that copper tubes were more durable than steel, but in the use of copper it was essential that it should be very pure, and that the tube, under all circumstances, should be below the level of the water and always filled, otherwise the copper might become overheated.

They had every reason to fear, from what they had been told, that trouble would be experienced in working a group of small rapidly-evaporating boilers in the *Hornet*, but, as a matter of fact, they had experienced no difficulty whatever, the feed being arranged in, as it were, two stages. The feed pumps on the engine take their suction from the hot-well, and deliver into a reservoir at 50 pounds pressure, and from this reservoir the donkeys take their suction, each boiler being provided with an independent donkey. By this means a very ample supply of water was always insured on the suction side of the donkeys, and the pipes leading to them could be of moderate dimensions, in consequence of the 50 pounds pressure delivering the water readily to the suction side of the pumps. To insure the reservoir always being well filled, there was a small amount of auxiliary feed constantly passing into it, the surplus, beyond that which was necessary for the supply of the boilers, being returned to the tank through a relief valve loaded to 50 pounds.

The first one of these boilers built was put into a second-class torpedo boat for the Argentine Government. This boiler had a steam drum 6 feet long and 20 inches diameter, and had galvanized steel tubes. The boat was 60 feet long and 9 feet 3 inches beam, and had a load displacement of 15 tons. Her speed on trial, carrying a load of 2 tons, was 18.113 knots with 250 I. H. P.

A number of boilers of this type are now in course of construction for other British first-class torpedo-boats, and it is reported that Mr. Yarrow has entered into contract with the Russian Government to build a torpedo-boat of 29-knots speed.

Another type of Yarrow boiler is shown in fig. 24. It is somewhat on the style of the Lagrafel-D'Allest boiler, except that the drum is across the tubes instead of in the direction of their length and that the flat surfaces of the water spaces are braced by the tubes, which pass through the two sheets and are expanded into them. The outer ends of the tubes are plugged, and each tube, where it passes through the water space, has an opening through its upper and lower sides.

THE BLECHYNDEN BOILER.

This boiler is shown in fig. 25. It differs little in principle from the Yarrow boiler. The construction, however, is different; instead of the steam and water drums being made in two parts, with bolted flanged joints, the two parts of the lower drums are riveted together, as are also the two parts of the steam drum. The latter is made much larger than in the Yarrow boiler, and is provided with two rows of holes along

its upper surface through which any tube may be removed. The tubes are drowned and are slightly curved, and the two outer rows, which act as downflow tubes, are arranged very much like the outer rows of tubes in the new Thornycroft boiler. Boilers of this type will be fitted in three torpedo boats building for the British Government by the Naval Construction and Armaments Company.

THE LAGRAFEL-D'ALLEST BOILER.

This boiler, shown in fig. 26, is similar in many respects to the Babcock & Wilcox, the headers in the latter being replaced by plate water chambers stayed in the manner usual with the flat water surfaces of cylindrical boilers. The holes in the outer plates are secured by hand hole plates placed inside the boiler, the joint being made with a thin asbestos washer and a ring of thin copper wire.

Mr. Milton, from whose paper the illustration is taken, says of this boiler:

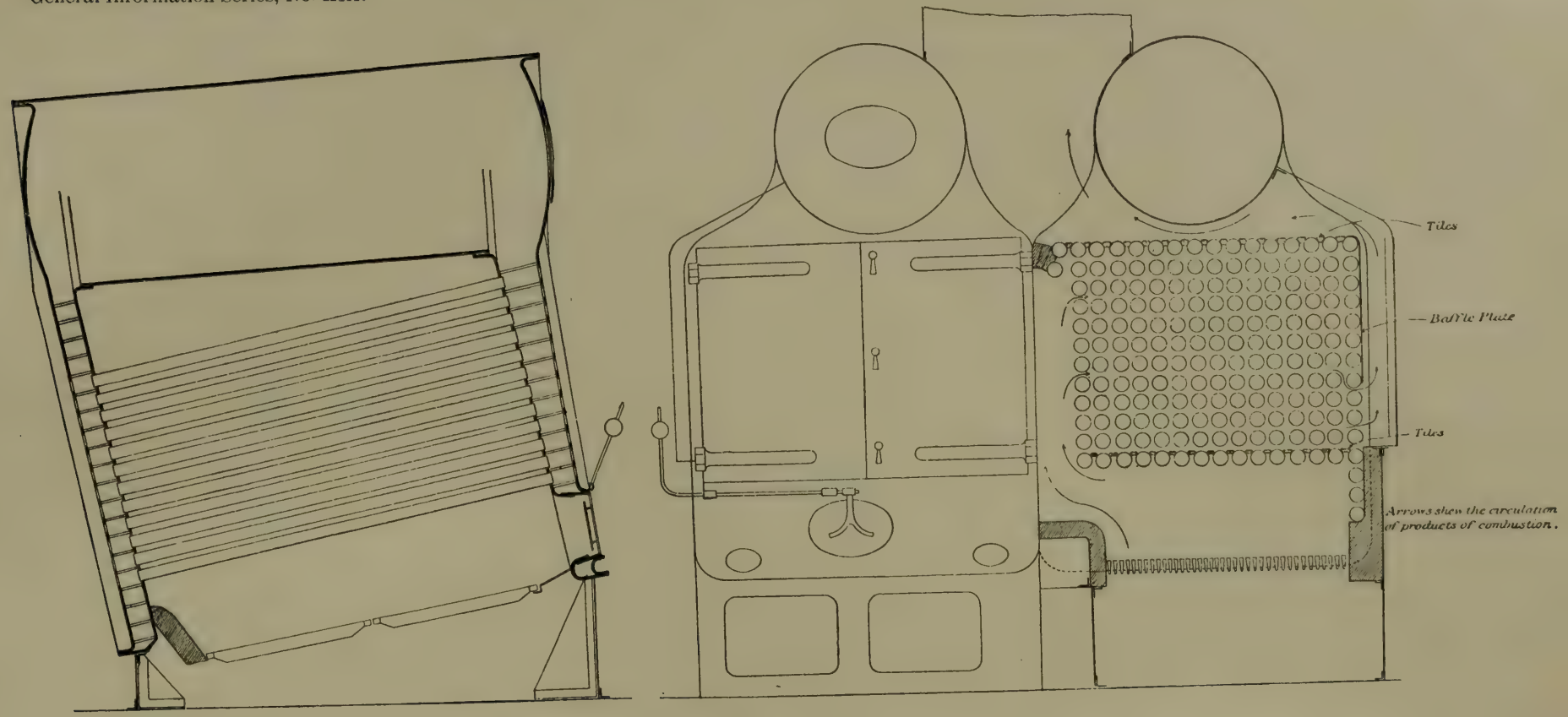
It should be noted that there are no stay tubes in this boiler. The water chambers are each connected to the horizontal steam chest at their upper portions, and at this part, therefore, do not need such stays. At the lower parts the necessary strength to resist separating the slabs is obtained by the friction of the tube joints, which are all expanded or rolled joints. The tubes generally employed are about 2.75 inches outside diameter, one-fourth inch thick, and are pitched about 4 inches apart from center to center. "Serve" tubes are recommended by the makers for the lower row of tubes.

The working water level is a little above the bottom of the receiver, and the circulation of the water and steam is such that the water supply enters each tube at its lower end from the back water space, passes along the tube, where part of it is vaporized, the mixture of steam and water escaping into the other water chamber and rising direct into the receiver without having to pass through the upper tubes, as in the Belleville boiler. The water so carried over traverses the bottom of the steam receiver and passes down the other water chamber, where the process is repeated.

The feature distinguishing this boiler from all others is the arrangement made for the circulation of the products of combustion amongst the tubes. The boilers are usually arranged in pairs, each part having its own feeding and water circulation independent of the other; but a combustion chamber is common to the fires of both parts, being arranged between the two nests of tubes.

The tubes are placed mainly over the fire, the bottom row being at a height of about 2 feet above the grate bars. Over the bottom row of tubes and resting on them, preventing the passage of the gases between the tubes, are placed a number of specially-shaped tiles, and a similar set is fitted upon the top row. Baffle plates are fitted to cover the spaces between the tubes for about the upper two-thirds of their depth at the sides remote from the combustion chamber. These arrangements are shown in fig. 2, the arrows showing the direction which the products of combustion are compelled to take. They pass under the lower row of tubes into the combustion chamber, thence they proceed sideways between the tubes, emerging at the lower edge of the side of the nest of tubes, whence they proceed under the steam chests on their way to the chimney.

In the Lagrafel, which was the older form of this boiler, the products of combustion passed directly from the fire up amongst the tubes, as is now done in some other forms of water-tube boiler. The reason for altering the design was owing to its



ENLARGED VIEW OF TUBES AND TILES.

Fig. 26.—THE LAGRAFEL-D'ALLEST BOILER.

being considered that the gases immediately arising from the fire have not been properly burned, and that by passing them directly amongst the tubes they become cooled below the critical temperature at which union between the gases and the oxygen of the air takes place; so that imperfect combustion and loss of economy result. If this is so in practice, most of the other types of water-tube boiler must be inefficient from this cause.

The interior of the tubes and water chambers can be readily examined or cleaned through the numerous small doors, and the removal of any tube in case of necessity can be made in a short time, the tube being either replaced or the holes plugged.

The following table is given by Mr. Milton as the result of experiments made at Marseilles under the direction of French naval officers with a boiler forming one of a set intended for a French naval vessel:

Various particulars of experimental trials made with D'Allest boilers.

Description of boiler.	Duration of experiment.	Grate surface.	Heating surface.	Total weight of boilers, including all mountings, casings, chimney, and water.	Total weight of boilers per square foot of heating surface.	Consumption of Cardiff coal per square foot of grate per hour.	Actual evaporation of water per pound of coal.	Equivalent evaporation from and at 212° F.	Equivalent evaporation per square foot of heating surface per hour.
	Hrs.	*Sq. ft.*	*Sq. ft.*	*Tons.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Experimental boiler	6	35.9	1,076	.....	.....	10.29	10.67	12.44	4.28
Do	6¾	30.8	1,076	.....	.....	15.15	9.58	11.15	4.84
Do	6	35.9	1,076	.....	.....	15.50	9.23	10.83	5.60
Do	6	43.0	1,076	.....	.....	15.36	8.97	10.43	6.41
Do	3	35.9	1,076	.....	.....	25.09	8.02	9.42	7.86
Do	3	35.9	1,076	.....	.....	31.00	8.75	10.28	10.61
Part of installation of vessel of		Total in vessel							
2,000 I. H. P.	3	100.75	4,090	42.1	23	45.75	8.24	9.39	10.59
Do	3					35.84	9.07	10.34	.....
Do	8					15.36	9.43	10.75	.....
Part of installation of vessel of		Total in vessel.							
9,000 I. H. P.	6					20.48	9.80	11.26	.....
Do	12	645	21,528	288.8	30.5	12.30	10.07	11 53	.....
Do	3					24.60	9.50	10.86	.....
Do	3					30.72	9.23	10.58	9.70

These boilers are being fitted in a number of French naval vessels, the *Bouvines*, *Jemmapes* and *Valmy*, each having twelve of 8,300 indicated horse power, *Carnot*, twenty-four of 14,000, and the *Jauréguiberry*, twenty-four of 13,000. The tubes are from 3 to 3.25 inches in diameter. They have been successfully fitted in the *Bombe*, where two of them of 2,000 I. H. P. replaced the locomotive boilers of that vessel, which had given trouble from the day they were put in. With these boilers the *Bombe* is said to have made 19.2 knots, her speed with the locomotive boilers having been from 17.5 to 18 knots.

The boilers of the *Jauréguiberry* contain 1,085 square feet of grate and 35,092 square feet of heating surface, and are intended to work under a pressure of 213 pounds, which will be reduced to 170 at the

engine; the tubes are 3.15 inches in diameter and 8 feet long. The weight of the boilers alone is 235 tons; of the smoke boxes, 99; feed pumps, pipes, and floors, 138; and water, 80 tons.

THE ORIOLLE BOILER.

This boiler, shown in fig. 27, is similar to the Lagrafel-d'Allest, except that there is no steam drum connecting with the front and back water spaces, the steam being led to a drum outside the boiler by means of the pipe shown at the back end. The tubes are about 2 inches in diameter, are staggered in order to prevent the rapid escape of the heated gases, and are expanded as in the Lagrafel-d'Allest boiler. The water level is carried below the upper row of tubes. This boiler has been fitted in some French yachts, but thus far has not been successfully used in a naval vessel. The torpedo boat *Lansquenet* has four of them, aggregating 143.4 square feet of grate, and 5,920 of heating surface; they were designed for 2,000 I. H. P., but thus far the boat has failed to come up to expectations, and is now undergoing alterations to her engines and boilers.

THE DU TEMPLE BOILER.

The type shown in fig. 28 is the one which has been fitted in a number of French torpedo boats. The tubes are each of two diameters, the lower end connecting with the water chamber at the side being smaller than the upper. The upper ends deliver near the water line.

Two boilers of this type have been fitted in the French torpedo boat *Chevalier*, built by Normand. On trial, with a displacement of 119 tons, she made a speed of 27.22 knots. The engines were not indicated, but the I. H. P. was estimated at from 2,700 to 2,800, the coal burned per square foot of grate being upwards of 62 pounds per hour. Each boiler has 43 square feet of grate and 1,644 of heating surface.

A few particulars of a boiler of this type were given before the Institution of Civil Engineers in England a few years ago. The boiler had a steam drum 27½ inches in diameter, contained 28 square feet of grate and 904 square feet of heating surface, and weighed, with water, 15,400 pounds. Upon a test with 3.5 inches of air pressure it burned 1,650 pounds of coal per hour with an evaporation, at 140 pounds pressure, of 6.33 pounds of water per pound of coal. The temperature of the feed was not given.

An outline sketch of the latest type of this boiler is shown in fig. 29. As will be seen, it differs little from the "Unique" type of Ward boiler illustrated in fig. 2. The principal difference is that all the tubes are drowned, that there are outside circulating tubes, and that the Du Temple tube of two diameters is retained.

In this type, cylindrical water reservoirs are substituted for the rectangular ones at the bottom, and plates arranged so as to reach each

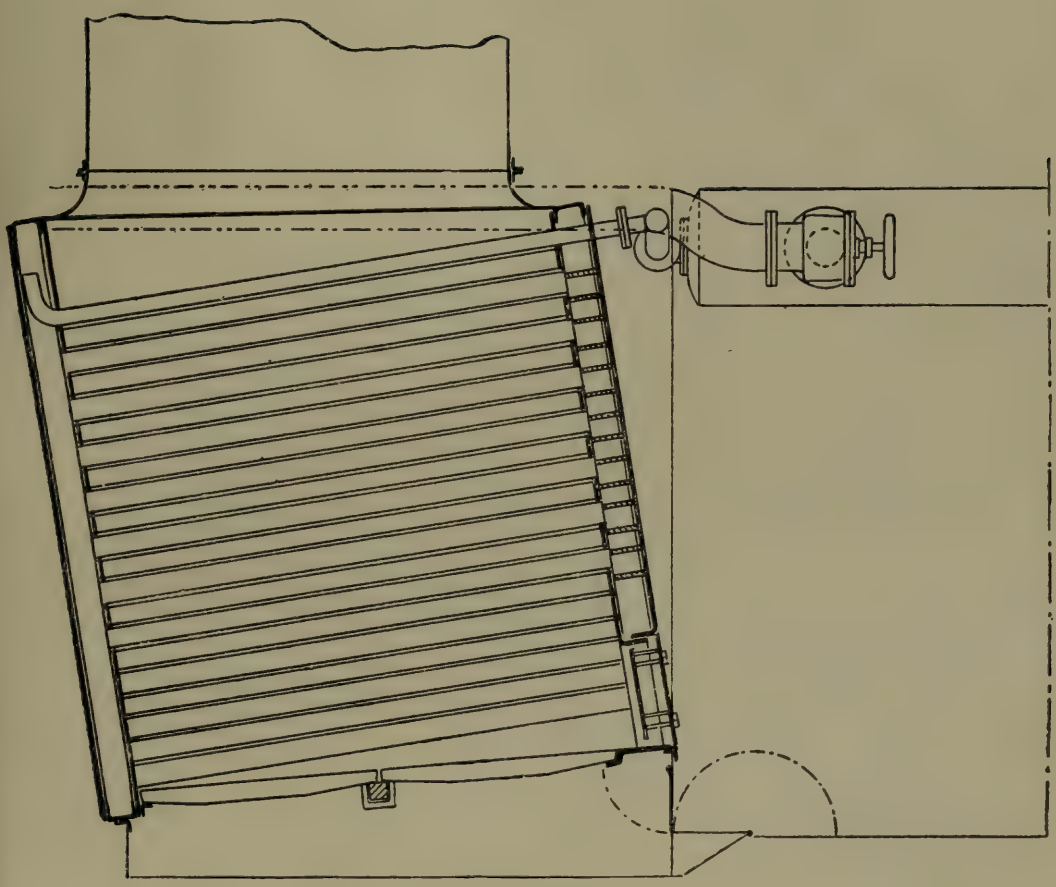


Fig. 27.—THE ORIOLLE BOILER.

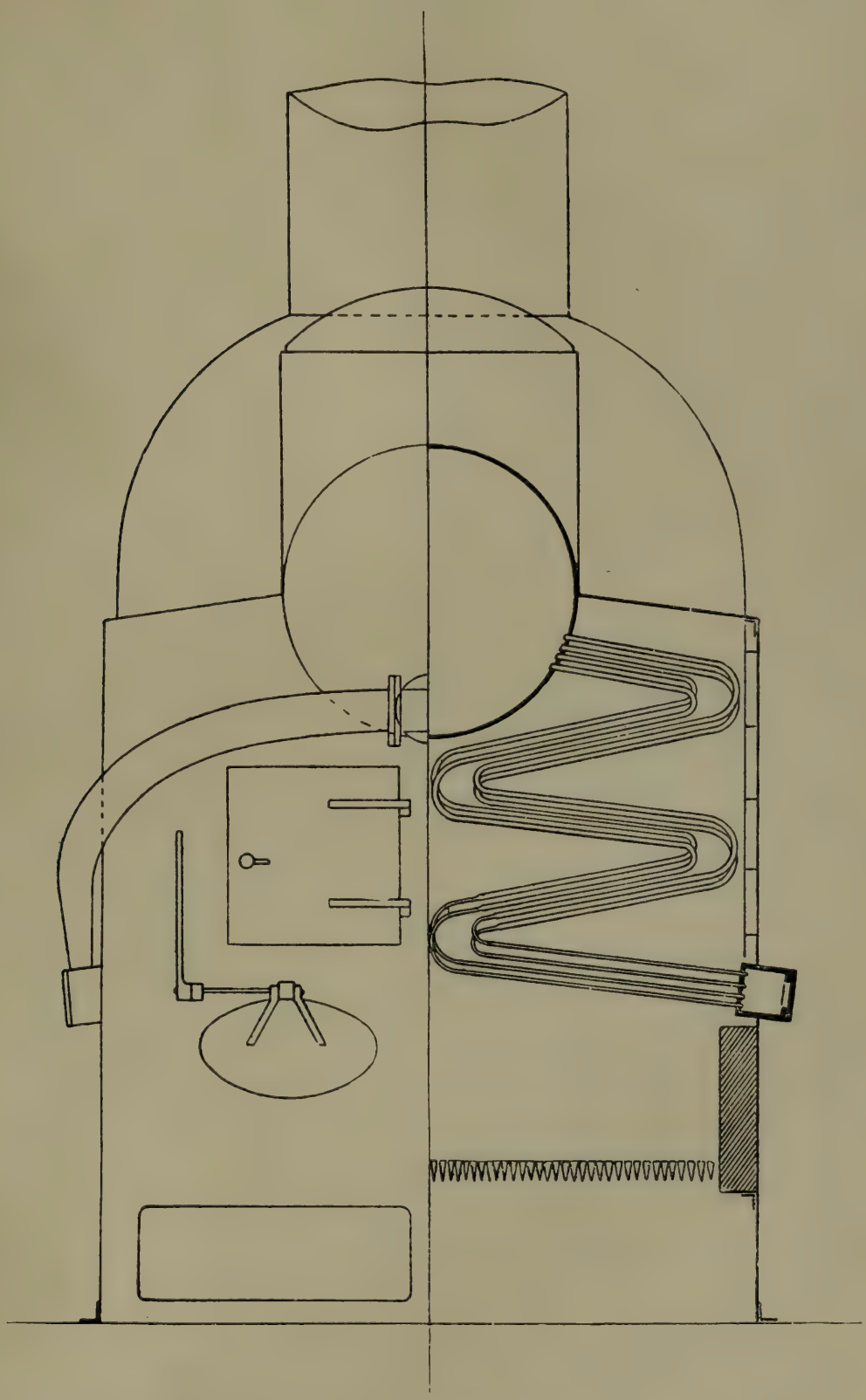


Fig. 28.—THE DU TEMPLE BOILER.

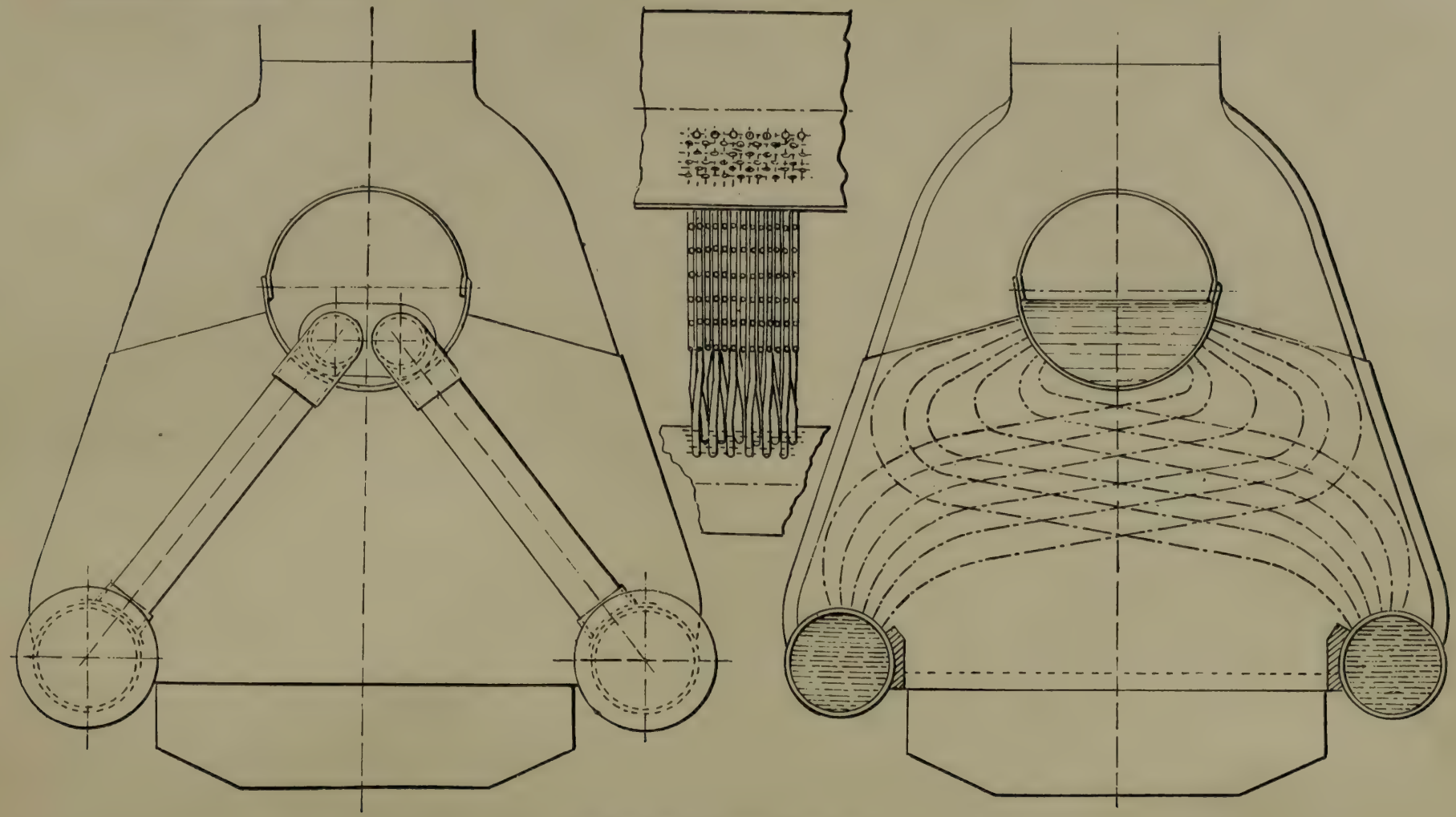


Fig. 29.—THE DU TEMPLE BOILER.

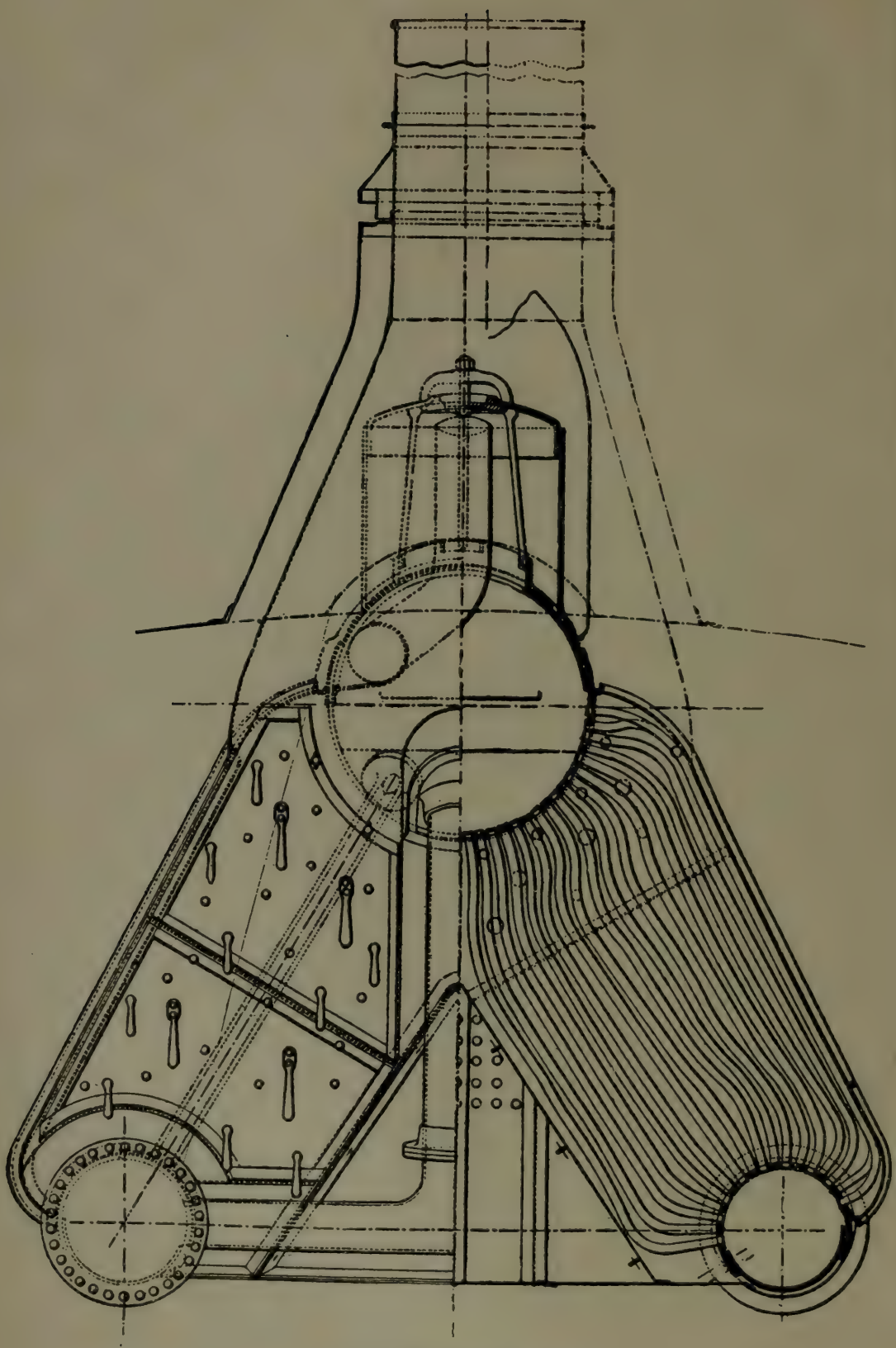


Fig. 30.—THE NORMAND BOILER.

tube end in case of necessity. Perforated baffle plates are fitted above the tubes so as to retard the passage of the gases.

Another recent patent retains the zigzag form of tube of the earlier boiler, but with the cylindrical water drums, and the nest of tubes extended beyond the grate. Baffle plates are fitted between and above the tubes. The tubes of this boiler are 1.18 inches diameter and 0.1 inch thick.

Boilers of the Du Temple type are to be put in the British torpedo vessel *Spanker*, replacing locomotive boilers, and also in some of the first class torpedo boats now under construction.

THE NORMAND BOILER.

This boiler is shown in fig. 30, and is so much like the Thornycroft boiler as to render a description unnecessary. It has outside circulating pipes as in the old Thornycroft, but differs from it in having all the tubes drowned, resembling the Yarrow in this respect, except that the tubes are not straight.

One of these boilers has been fitted on a French torpedo boat, *No. 149*, of 75 tons displacement, and is reported to have given good results on trial. The boiler has 35.7 square feet of grate and 1,894 square feet of heating surface, and, on trial for two hours, furnished enough steam to a triple-expansion engine, 16, 23, and 31½ by 18 inches, to make 339 revolutions and give the boat a speed of 24.51 knots. The air pressure was 2.5 inches, and the coal burned upwards of 71 pounds per square foot of grate. The tubes were of brass and copper. Boilers of this type are also to be put in the torpedo boat *Forban*, of 130 tons displacement, in which Mr. Normand has guarantied a speed of 30 knots an hour with 3,200 I. H. P. As a result of the experience with brass tubes, no more will be used in the Normand boiler, steel being substituted. The arrangement of the tubes is such that the gases go the full length of the boiler and then return amongst the tubes to the smoke pipe at the front end.

This type of boiler is also in use in the British first-class torpedo-boat *Ferret*, the I. H. P. of whose engines on a recent trial was 4,490, with a pressure of 169 pounds in the boilers.

THE WHITE BOILER.

This boiler, which will be put in three of the British first-class torpedo boats, is shown in fig. 31. It has the usual upper steam and water drum, and a water drum on each side of the furnace connected to the upper drum by a series of coils, so arranged that the products of combustion have to pass down the furnace and back between the coils to the smoke pipes, which are at the front of the boiler. There are outside circulating pipes as in the original Thornycroft boiler.

THE NICLAUSSE BOILER.

This boiler is shown in fig. 32. Though in use in the French navy on board the *Friant*, *Charles Martel* and *Elan*, there are few details of its

practical working, and thus far it has been used only with natural draft. The circulation is down the outer division of the front header, through the central tubes, back through the space between the inner and outer tubes, and up the inner division of the header to the steam drum.

There are many other water-tube boilers in France which are being experimented with in the navy, but thus far none of them have been used long enough to determine whether they will prove efficient for naval vessels. One, the Babillot, a forced-circulation boiler, with tubes arranged somewhat in the same manner as in the Niclausse, was tried in the torpedo boat *Sarrasin*, but with such fatal result on the official trial that it has been taken out and a different type substituted.

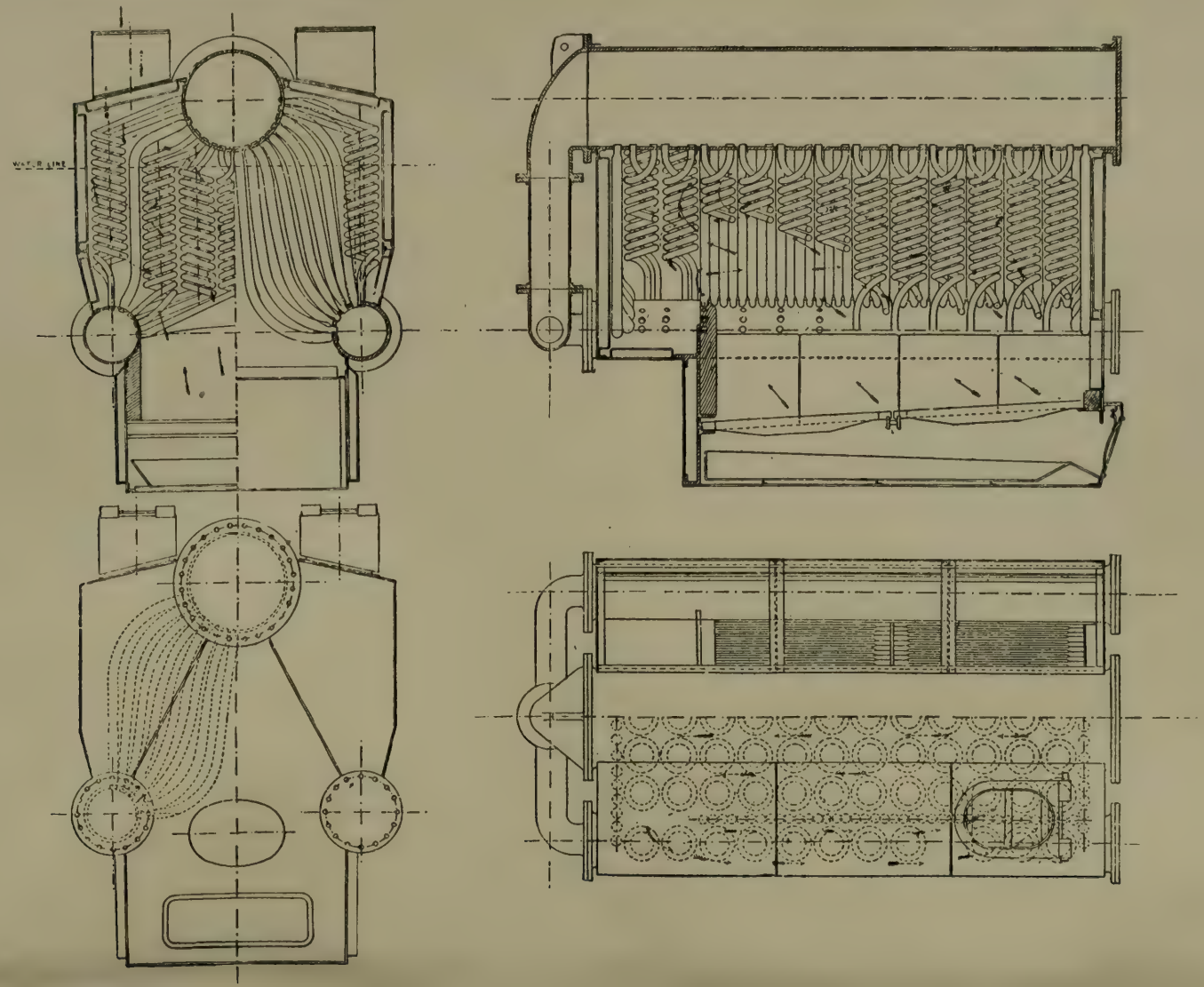
THE FLEMING AND FERGUSON BOILER.

A type of water-tube boiler designed for use in merchant steamers, and in places where considerations of weight are not important, is that of Fleming and Ferguson, shown in fig. 33. The tubes are 2.5 inches in diameter and are drowned, and the size of the upper and lower drums such that a tube can be readily cut out and renewed, the diameter of the upper drum being so large that any tube in the boiler can be passed through it and put in place. The illustration shows but one type of the boiler, all of which are on the same general plan, though arranged to fire differently and also as a double-ended boiler. Two of these boilers are now being fitted on board a steamer building in Scotland by Fleming and Ferguson.

The following table gives some particulars of the different types designed by the makers:

Type of boiler.	Working pressure (pounds per square inch).	Heating surface.	Grate surface.	Total weight of boiler and contained water (cold), with casings, and all mountings and fittings, except chimney.	Total weight per square foot of heating surface.
		Sq. feet.	*Sq. feet.*	*Tons.*	*Pounds.*
Navy type, 1 furnace	200	1,150	30	21	41
Two boilers for steamer, where height and width are kept a minimum, both	200	*1,450	*44	*34	52
Single-ended boiler, with 2 furnaces	200	1,150	48	23	45
Double-ended boiler, with 4 furnaces	200	2,200	88	38	39
Single-ended boiler, with 3 furnaces	200	1,550	60	31	45
Double-ended boiler, with 6 furnaces	200	3,400	110	55	36
Double-ended boiler, with 6 furnaces	200	4,800	138	75	35
Boiler being made, as per fig. 33	220	1,450	50	30	46
Large boiler, with 4 furnaces fired crossways	250	5,000	165	110	49

* 2 boilers.


WATER LINE

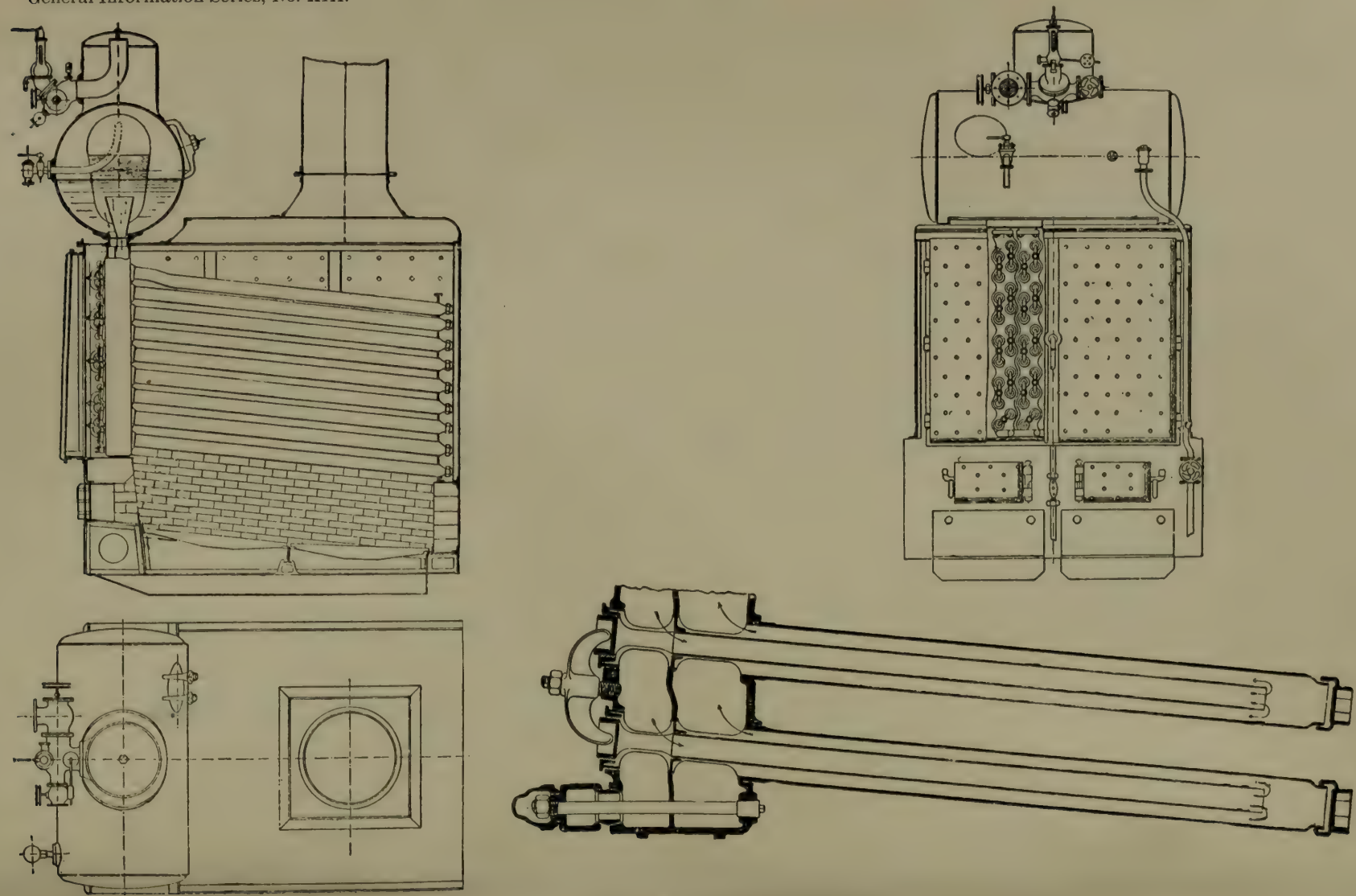


Fig. 32.—THE NICLAUSSE BOILER.

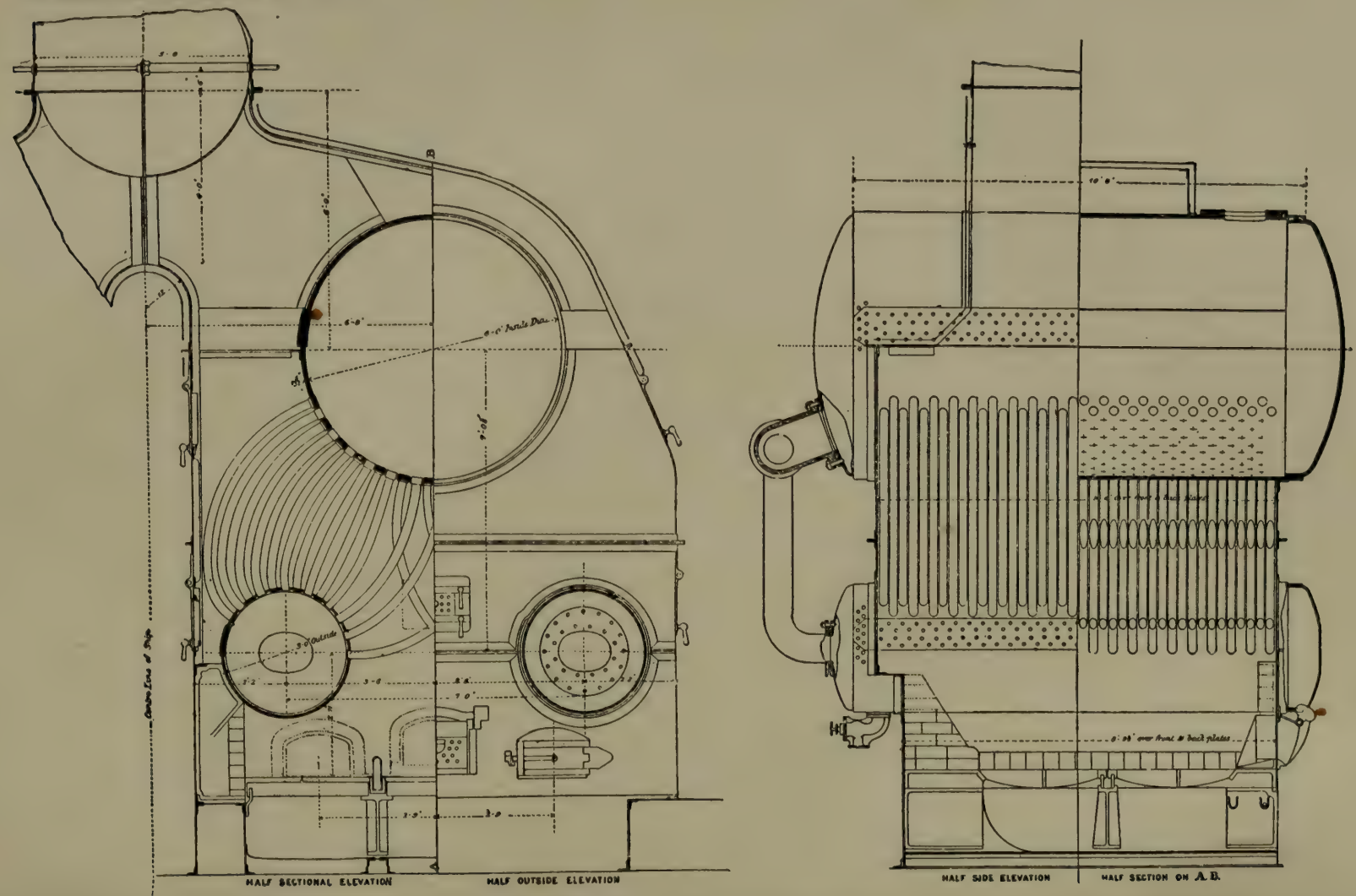


Fig. 33.—THE FLEMING AND FERGUSON BOILER.

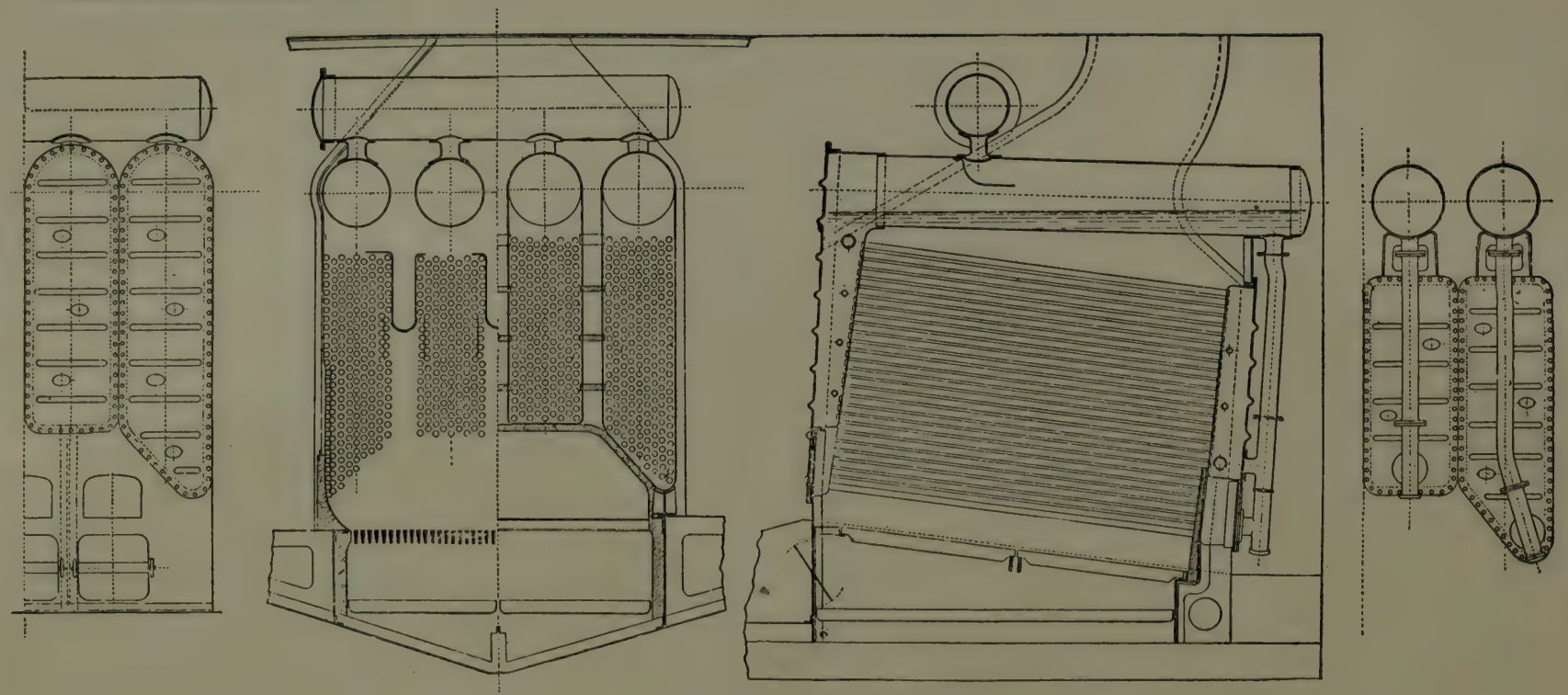


Fig. 34.—THE SEATON BOILER.

THE SEATON BOILER.

This boiler, which was described in Mr. Milton's paper, before referred to, is shown in fig. 34. In many respects it bears a striking resemblance to the Lagrafel-D'Allest. The most important points of difference are that there are no stays for the water spaces at the front and back, and that the back water space, instead of being directly connected with the drum, is supplied by a circulating pipe back of it. The covers of the front and back water spaces are ribbed, and are arranged to be removed so as to reach the tube ends. The boiler is still in the experimental stage, and no details of its performance have yet been published.

VII.

CONCLUSIONS AND RECOMMENDATIONS OF THE COMMITTEE APPOINTED BY THE LORDS COMMISSIONERS OF THE ADMIRALTY TO CONSIDER EXISTING TYPES AND DESIGNS OF PROPELLING MACHINERY AND BOILERS IN HER MAJESTY'S SHIPS.

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5 Craigs Court, Charing Cross, *December 9, 1892.*

The committee appointed by the Lords commissioners of the Admiralty to consider existing types and designs of propelling machinery and boilers in Her Majesty's ships, and to make suggestions for the improvement of the same in future, have now the honor of submitting their final report on the several points referred to them.

As the reduction of working steam pressure mentioned in inclosure to admiralty letter S. $\frac{3066}{3362}$, of March 15, 1892, would, if adopted, effect a radical alteration as regards the machinery and boilers supplied for some time past to our war ships, the committee first express their opinion on the definite points raised in this inclosure, beginning with the most important, viz: "Taking all the circumstances of the service for which Mer Majesty's ships are designed into account, is a reduction of the present working pressure considered desirable; and, if so, to what extent? If the committee should be of opinion that a reduction of pressure is not desirable, the reasons for arriving at this conclusion should be stated."

(*a*) The relative economy in working with high and low pressure steam (each in connection with the type of engine suitable for the pressures under consideration) being of the utmost importance, considerable time has been devoted in the examination of witnesses and analysis of the admiralty records to elucidate this matter as far as possible. This important question is considered under two heads: (1) for full-power working; and (2) for low-power working, which is so important a feature for war ships.

(*b*) As to economy at full power, all the evidence obtained has been to the effect that a gain in economy has resulted from each successive increase of steam pressure. The replies of the large steam shipping companies show that in the mercantile marine there is an advantage of 20 per cent. in triple-expansion engines using steam of 150 pounds pressure and above, as compared with bi-compound engines using steam of 90 to 100 pounds pressure, and about 25 per cent. as compared with the older bi-compound engines using steam of 60 pounds

pressure. The witnesses examined also state the average saving to be 20 per cent. by the use of the triple-expansion as compared with the bi-compound engine.

The admiralty records for an extensive series of trials made in ships fitted with compound and triple-expansion engines confirm, for naval engines at high powers, the results, as regards economy, obtained in the mercantile marine.

From all the evidence the committee consider it established that there is a saving of from about 20 per cent. at high powers to about 17 per cent. at low powers by the use of the high-pressure triple-expansion engine, as compared with the 60 pounds bi-compound engine working at similar low powers.

The committee call attention to the increase in coal consumption per I. H. P. on ordinary low-power service, which results in cases where there is a great disproportion between the maximum power and that required for such service.

The triple-expansion principle reduces vibration and the strains on bearings and engine shafting, and thus makes a smoother working engine. Experience shows that the wear and tear with the high pressures is generally no more than with low pressures, and in many cases it is less.

In the opinion of the committee the use of the higher steam pressures has but little to do with the causes of leaky tubes, for, omitting defects due to design of boilers and details of tubes which equally affect all pressures, it is considered that the tube ends will leak in high or low pressure boilers, if the amount of power attempted to be obtained from them exceeds certain limits. When these limits are exceeded the tube ends and tube plates become overheated owing to the increased generation of steam rendering the local conditions of circulation unable to maintain an adequate flow of water over the surface of the tube plate, and this they regard as the primary cause of the leakage of boiler tubes. It should not be overlooked that concurrently with the increase of steam pressures in our war ships, the powers obtained from their boilers were sometimes unduly increased by forced draft, and the leakage of tubes which followed in consequence should not, in the opinion of the committee, be considered as caused by high pressure.

The use of fresh water is very desirable in order to prevent the formation of deposits on the heating surfaces, so that ships may always be ready to proceed on any service without delay due to cleaning of boilers. Its use will also be found economical in reducing the labor of cleaning the internal parts of boilers, it being difficult to make some of these spaces sufficiently large and accessible as to be readily and efficiently cleaned.

There is no doubt that increased trouble has been in many cases experienced with the higher steam pressures, from leaky steam-pipe joints, glands, etc., these not being proportioned to suit the increased

pressures. Losses of fresh water and other inconveniences followed, the evaporating plant not being sufficiently large to meet this contingency. Too much attention can not be given to these details.

In the opinion of the committee it is desirable that all ships having surface condensers should be supplied with the means of avoiding the use of sea water for replenishing the waste of feed water, and thus insuring the ships being always in readiness for service, as the advantages gained are more than commensurate with the expense incurred, while the inconvenience caused by the necessity of frequent supplies from the shore will also be removed by the vessels being made self reliant as regards the production of made-up feed water.

It has been stated that "the draught of water of the ships carrying a reserve of fresh water in tanks has been increased." Respecting this question the committee consider that if their recommendations as to size of evaporators, detailed later on, be accepted by the admiralty, there will be no necessity for carrying so large a supply of reserve fresh water in tanks. By raising the power of the evaporating plant to the maximum required, it is considered that the size of these tanks need not generally exceed that required to contain one-fourth of the water carried in the boilers at working level, with a minimum stowage of the capacity of one boiler at working level.

The committee are of opinion that a reduction of working steam pressure to 60 pounds is both undesirable and unnecessary, and as any smaller reductions would be also accompanied by similar though smaller losses of efficiency, they consider that no reduction should be made, there being no serious troubles from the use of high-pressure as compared with low-pressure steam, other than due to insufficient provision of fresh water, which can be easily remedied by the proper supply of evaporators, as previously referred to and detailed later on.

The committee consider that the existing types of triple-expansion engine fairly meet the requirements, but for improvement of future designs offer the following suggestions:

As bearing on the important question of the economy of the engines at low powers, and preventing undue strains being brought on boilers and machinery by the development of powers for which they were not intended, it is recommended that the size of cylinders and cut-off of steam should, as far as possible, be so arranged that no more than 5 per cent. beyond the specified full power should be capable of being attained with valves fully open and everything in full gear. In the past too great a margin has often existed between the specified full power, and that which the engines were capable of exerting, and by this means their economy at low powers has been impaired.

It is considered that a ratio of low-pressure to high-pressure cylinder volume of about 5 is the most suitable for 155 pounds steam pressure, this ratio being a fair compromise between the requirements of the development of high power on a moderate weight and space, and low

powers with as much economy as possible. With this ratio of cylinders the cut-off in the high-pressure cylinder at full power should be such as to make the mean equivalent pressure on the low-pressure piston about 37 pounds per square inch.

Various suggestions have been carefully considered for increasing the efficiency of the engines at low powers, while retai ng the capacity for the development of the maximum power at short notice. Several of these suggestions involve disconnecting the low-pressure engine. This is not recommended, as it is considered that the practical disadvantages outweigh any possible gain in economy.

The trials of *Thunderer* show that her engines, as at present arranged, can be made to work economically at low powers, but as it is considered that the performances generally of Her Majesty's ships are capable of some improvement at these powers, the following device for securing the desired end is recommended, viz: To design the slide valves, eccentrics, and gear to give the natural-draft power with the best distribution of steam in lead, admission, release, and cushioning, and to obtain the extra power beyond natural draft by over linking or its equivalent, thus increasing the travel of the valve and securing a later cut-off.

As regards the speed of the engines at full power, the committee consider the speeds specified for the existing types satisfactory. With present experience, however, they do not recommend any higher speeds.

As regards the compactness and accessibility of the machinery, the strength of the various parts of engines and boilers, and the amount of bearing surface allowed, there is no evidence of any insufficiency except as regards the gudgeon bearings of connecting rods. It is considered the action now taken by the admiralty in fitting wrought-iron case-hardened gudgeon pins instead of soft steel will remedy the defects which have occurred in this part of the machinery.

The committee recommend the fitting of the evaporating plant in at least two parts, and in large ships three parts. These should be fitted so that they can be worked "in series," to obtain a higher efficiency when a less amount of water is required than the maximum output. To enable this to be conveniently done, their arrangement should be specially considered when the machinery is being designed for the vessel.

(*a*) From the evidence obtained, it appears that if the machinery is in proper condition the waste of water should be well within 6 tons per day per 1,000 I. H. P. In some ships it is much less, but the amount varies greatly according to the state of the machinery.

(*b*) It is therefore recommended that the evaporators should be capable of producing at least 6 tons of water per day per 1,000 I. H. P. at the specified natural-draft power. As these high powers would only be run for comparatively short periods, it is considered that this amount will provide sufficient water for the boilers under ordinary conditions and also allow a liberal quantity for ship's purposes, the latter being

supplied from the ship's tanks on the occasions when the full natural-draft power is being used.

(*c*) In cases where the number of men to be provided for is exceptionally large in proportion to the horse power of the ship, additional evaporative power should be provided, so that the evaporators will, besides supplying a liberal quantity for ship's purposes, be capable of making at least 6 tons of water per day per 1,000 I. H. P. at three-fifths natural-draft power.

(*d*) To insure the apparatus being of proper size under the conditions of service at sea, it should be capable in the makers' shops, when new, of producing one-third more than the preceding quantities, this being in accordance with the present practice.

(*e*) The above recommendations are based on the assumption that fresh-water condensing apparatus will be fitted in excess of the requirements of the ship's company, so that when required, the ship's drinking-water tanks may be filled from this apparatus so as to enable the water for ship's use to be supplied from these tanks, and the full production of the evaporators, therefore, made available for supplying the feed-water make-up for the short periods during which high powers are run.

In order to insure efficient feeding of the boilers, it is recommended that the feed pumps should be of such size that they will work at moderate speed at full power with one-half the pumps at work, and that the main feed pumps be fitted with automatic speed-controlling gear when practicable.

To reduce the strains on the boilers when raising steam, and also enable steam to be raised more rapidly without injury when required on emergencies, it is considered that connections should be fitted from the auxiliary feed pumps to enable them to circulate the water by pumping it from the bottom of the boilers back again through the auxiliary feed valves.

The types of boilers fitted in the ships undermentioned have been carefully considered, viz: Battle ships, *Royal Sovereign*, *Barfleur*, *Hercules*, and *Monarch;* first-class cruisers, *Edgar* and *Crescent;* second class cruisers, *Latona* and *Hermione;* single-screw gunboats, *Thrush* class; torpedo gunboats, *Jason* and *Halcyon*. It is considered, omitting matters of detail which will be dealt with later on, that they are all suitable for the naval service.

The following remarks are, however, made with a view of indicating what is considered to be the relative merits of the various types of boilers fitted, with reference to future designs.

The battle ships are fitted with 4-furnace single-ended return-tube boilers of three types, viz: Those in (1) the *Royal Sovereign*, *Hercules*, and others, having 2 combustion chambers; (2) the *Resolution* and *Revenge* having separate combustion chambers for each furnace; and (3) the *Royal Oak*, with 3 combustion chambers for the 4 furnaces, the 2 middle furnaces delivering into 1 chamber. Of these boilers the committee consider type 2 to be the best.

The first-class cruisers are all fitted with 4-furnace boilers of type 1 (the early ones with double-ended boilers and a small single-ended auxiliary boiler, the later ones with single-ended boilers). It is considered that they would be improved by fitting a separate combustion chamber to each furnace as in type 2, or by fitting three combustion chambers as in type 3.

The second-class cruisers each have 3-furnace boilers, some of them with single ends and others with double ends. All have a separate combustion chamber to each furnace, and these types are considered to be well suited for the naval service.

The gunboats of the *Thrush* class are fitted with navy boilers with 2 furnaces; this type is considered to be satisfactory, but some members consider it would be improved by fitting a separate combustion chamber to each furnace, while the other members think such alteration unnecessary.

The torpedo gunboats of *Jason* class are fitted with wet-bottom locomotive boilers having divided furnaces; this type is considered to be suitable for the requirements of such vessels.

The committee have stated their general preference for a separate combustion chamber to each furnace in return-tube boilers, but they consider, however, that the double-ended boiler with combustion chambers common to each pair of opposite furnaces is also an efficient type.

The committee consider that either single or double-ended boilers of the types mentioned above will be satisfactory, but that for greater subdivision of power single-ended boilers are to be preferred where the extra weight can be allowed.

They further consider that where the extra space required can be given, 3-furnace boilers are superior to, and should be adopted in preference to 4-furnace boilers. The latter should be fitted only for ships in which a limitation of the floor space occupied by the boilers is so important as to necessitate the employment of very large boilers, in which 3 furnaces, if fitted, would be too large in diameter.

As regards the size of boilers recommended, the return-tube boiler is first considered under the heads of (*a*) heating surface, (*b*) grate surface, and (*c*) steam space.

(*a*) As to heating surface, the committee consider that an amount of total heating surface equal to about 2.5 square feet per I.H.P. at natural draft should be provided.

(*b*) As to grate surface, an area equal to about one thirty-third of the total heating surface is recommended.

(*c*) As regards steam space, the present practice of the admiralty is considered satisfactory.

For the navy-type boilers fitted in the sloops and gunboats, the present practice as regards heating surface, grate surface, and steam space at natural-draft power is considered satisfactory.

In the torpedo-gunboat type of boiler, a total heating surface of

2.5 square feet per I. H. P. at natural draft is recommended, and the present practice as regards steam space and grate area is considered satisfactory.

As regards water spaces (other than between adjacent tubes) it is considered that these might with advantage be somewhat increased from the sizes which have in many cases been recently fitted, in order to facilitate cleaning of the boilers and the free circulation of water.

(*a*) For return tube boilers it is recommended that these water spaces should not be less than in the boilers of the *Crescent*. In the case of 4-furnace boilers with 2 combustion chambers, as in type 1 referred to previously, each nest of tubes should have a water space down the middle of not less than 7 inches.

(*b*) For the navy type the water spaces should not be less than adopted in the boilers of the *Thrush*.

(*c*) For the torpedo-gunboat boilers of the *Jason* class the water spaces are considered satisfactory.

Tubes having a diameter of 2.5 inches outside, thickness of 0.16 inch, and distance apart in the vertical direction of 1 inch, for the return-tube and navy-type boilers, are considered satisfactory. As regards the distance apart in the horizontal direction, an increase is considered desirable. This distance is recommended to be not less than 1⅛ inches.

(*a*) For the torpedo gunboats it is considered that the diameter, thickness, and distance apart of the tubes as now being fitted in the *Jason*-class are such as will give good results, these dimensions having been considerably increased from the earlier examples of this type of boiler.

A large combustion chamber is advantageous, not only for the combustion of the gases, but for convenience of repairs, and it is considered that a larger combustion chamber than is generally used could be fitted with advantage, the gain derived from the more perfect combustion of the fuel gases more than balancing the extra space and weight involved.

(*a*) In return-tube boilers, with the proportions recommended, the combustion chambers should generally be not less than 2 feet 3 inches wide for those with separate combustion chambers, and 4 feet for double-ended boilers with opposite furnaces common, while for those of large size the width might with advantage be somewhat further increased.

(*b*) In navy-type boilers, the present practice of combustion chambers about 3 feet 3 inches long is considered satisfactory.

(*c*) In torpedo-gunboat boilers of the *Jason* class, the distance between the tube plate and the end of grate is considered to be satisfactory.

With the sizes recommended the committee consider that the specified forced-draft power should be limited to 25 per cent. beyond the specified natural-draft power with the return-tube and navy-type boilers, and 40 per cent. with the torpedo-gunboat type.

The committee recommend that in return-tube and navy-type boilers the length of grate should not exceed twice the internal diameter of furnace. They also recommend that the length of furnace should be such that the end of the grate will be at least 6 inches from the combustion chamber.

Steel tube plates five-eighths inch to thirteen-sixteenths inch thick are recommended for the combustion chambers of all boilers, the former being preferred if the staying can be arranged to suit this thickness.

As regards the material of boiler tubes, in many cases the decay of steel tubes from corrosion and pitting has been found to be more rapid than that of iron tubes; while, on the other hand, steel tubes have advantages in their capability of being removed for cleaning purposes, stretched, and replaced, which can not be done with iron tubes, so that for the latter important reason no change of material from the present practice of mild steel is recommended.

In connection with boiler tubes the following have been under consideration, viz: (*a*) The fitting of spiral retarders in the tubes; (*b*) "serve" ribbed tubes; (*c*) the combination of *a* and *b*

Only by careful experiment can it be determined whether the economy of coal due to fitting them is such as to warrant the extra weight, the interference with cleaning of the tubes, and the reduction of draft when fans are not required to be used.

The committee do not propose to delay their report by carrying out such experiments, but would, however, recommend that they be undertaken to elucidate the above points.

The various systems of supplying the necessary air to the furnaces for combustion of fuel have been carefully considered.

(*a*) As regards "induced draft" it is recommended that no further experiments be carried out, pending the approaching trials of the *Gossamer* with this system.

(*b*) With reference to the comparative merits of the "closed stokehold" and "closed ash-pit" systems, as the latter does away with the necessity for a closed stokehold with air locks, and difficulties with ventilation of bunkers when stokeholds are closed, the balance of advantage and disadvantage is considered to be such that the system is recommended for trial in a vessel.

(*c*) As to air-heating appliances, which are not applicable to the closed stokehold system, it is recommended that experiments be undertaken to show whether the benefit to be derived by their use is sufficient to compensate for the additional weight and space entailed.

Grease filters for the feed water are recommended to be fitted to all new ships.

The committee recommend the fitting of tubulous boilers in two vessels for experimental purposes.

It is considered that only those tubulous boilers that are fitted with straight tubes of comparatively large diameter, arranged so as to be

readily cleaned and examined, should be considered as suitable for trial with the view, if found satisfactory, to their being fitted in the larger class of war ship.

Having regard to the importance of the subject, the committee would recommend that these experiments be made without delay, so that data may be obtained for guidance as to the adoption or otherwise of this type of boiler. In view, however, of the requirements of the larger vessels, they further recommend that one at least of any new cruisers should be arranged to receive tubulous boilers, should the above trials prove satisfactory.

They also consider that the *Speedy* should be thoroughly tried as soon as possible, to determine if boilers constructed with small tubes are suitable for continuous service at sea.

The committee acknowledge the great assistance that has been so readily granted them by many of the leading engineers in the country, and by the various steamship companies and engineering firms, with their principals and officers, who have afforded them information of great value.

In conclusion the committee desire to place on record their high appreciation of the valuable and arduous services rendered by Mr. H. J. Oram, R. N., as secretary to the committee. His practical and scientific knowledge, and unremitting energy in obtaining from all sources the necessary information bearing upon the subjects under discussion, has materially assisted the committee in conducting the inquiry and framing their report, and they desire to bring these services to their lordships' favorable notice.

ALEX. BULLER,
Vice-Admiral and Chairman.
JOHN H. HEFFERNAN.
J. T. CORNER.
JAMES T. MILTON.
H. J. ORAM,
Secretary.

I fully concur in the above report, except as follows:

The proposals involved in the preceding recommendations considerably reduce the powers which are now obtained from a certain weight of boilers. For example, in the *Latona* class, which, as now designed, have given satisfactory results, the maximum power for the present weight of boilers would be reduced from 9,000 to less than 7,000 I. H. P., which appears unnecessary. I am of opinion that the *Latona's* boilers, as now fitted, are amply large for the requirements of the Admiralty, and, further, that those of the *Royal Sovereign* class are large enough for the maximum power of 13,000 horses, provided the boilers are fitted with the Admiralty cap ferrules, which have been proved to be effective in preventing leakage of tubes.

With reference to the type of boiler, I am of opinion that the double-

ended boiler, with opposite furnaces common, is a superior type to that with separate combustion chambers, and that the double-ended boiler with one common combustion chamber, as in *Vulcan*, *Thunderer*, etc., is an efficient type. The performances of the *Thunderer's* boilers since the Admiralty cap ferrules were fitted were highly satisfactory, the weight of water evaporated per pound of coal per hour being exceptionally high.

With reference to the use of high versus low-pressure steam for war ships, the fuller information obtained, and the investigations made by the committee, show conclusively the advantages to be obtained by the use of high pressures, and I fully concur in the conclusions on this point embodied in the above report.

W. CASTLE.

While fully concurring with the committee's report, I am strongly of opinion that all boilers intended for use in Her Majesty's navy should be tested by water pressure to twice the intended working pressure prior to their acceptance from the contractors, and that their scantlings, stayings, etc., should be such that no part thereof would be unduly strained when subjected to the test. These views, if accepted and acted upon, would tend to the factor of safety being raised, and to an improvement in the workmanship of the boilers, and also render practicable the application of a more severe test to high-pressure boilers on service, than is the practice at present, all of which would, in my opinion, be conducive to greater safety, more especially in the case of boilers which are difficult to clean and examine.

PETER SAMSON.

I fully concur in the report of the committee, except that I am of the following opinion respecting certain paragraphs, viz:

That a piston speed of 800 feet per minute for engines as fitted in the second-class cruisers, and 750 feet per minute for the engines fitted in the battle ships, should not be exceeded.

That for the required full power on emergencies the bearing surfaces of journals of crank shafts and connecting rods should be increased in the I.P. and L.P. engines up to 8 per cent., according to the relative proportion of power and weights under which these journals work.

That the main shafts, more especially the crank shafts, have too much material bored out of the center, whereby the strength is reduced to withstand the various strains, and I consider the bore should not exceed one-fourth of the diameter.

That the engine beds and framing might be increased with advantage 6 per cent.

As regards the strength of the various parts of the boilers, as in the *Royal Sovereign*, that they compare favorably with the rules for strength in the mercantile marine, except the cylindrical shells and the main longitudinal stays. The former should be increased 10 per cent. and

the latter 15 per cent., while the hydraulic test should be increased to one and three-quarter times the intended working pressure.

Do not consider 4-furnaced boilers as suitable for forced draft and closed stokehold, or practical working under full-power conditions in the service.

The 3-furnaced boilers, having furnaces from 3 feet to 3 feet 8 inches mean diameter as a maximum, should be fitted, having circumferential shells in proportion up to 15 feet diameter for practical working, under all conditions, and that 3 feet 6 inches is a preferable diameter of furnace generally for forced draft.

That the furnaces have separated combustion chambers, and where weight and space is limited for double-ended boilers, that a common combustion chamber to two opposite furnaces is preferable and practicable, as in use in the fast and hard-driven mail steamers in the Atlantic service, both with natural draft and closed stokehold and forced heated-air draft.

That the locomotive type of boiler in use in the service, worked under the conditions of "forced draft," is not suitable for torpedo gunboats in rough weather, being difficult to manage, on account of the large flat surfaces exposed to intense heat, large grates, and confined water spaces; for moderate weather, but with increased water spaces and shorter grates, they are suitable for short service if they have reliable feed appliances.

As regards the "navy" type, they are more suitable for rough-weather conditions, but that tubulous boilers, with tubes rising diagonally or slightly curved, where there is little or no tube plate exposed to intense heat due to large grates, will be found better adapted for large power for this class of vessel in rough weather and short service, provided the feeding arrangements are reliable.

That the present practice under forced draft should be the minimum capacity, and could be increased in some cases with advantage.

That these spaces are too little under forced draft, and recommend an increase.

That the water spaces round 2.5-inch tubes under forced draft should not be less than 1.25 inches.

That the specified forced-draft power should not exceed 10 per cent. above the specified natural-draft power in return-tube and navy-type boilers, and 15 per cent. in the torpedo-boat boilers, but in tubulous boilers it may be increased to 40 per cent., and that under these conditions the higher powers required in the service can be maintained at sea.

That the length of grate for practical working should not exceed 6 feet, and that where a high forced-air pressure is necessary this length should be reduced; the furnace tubes containing the grate should not be less than 7 feet 6 inches in length, increasing in proportion to the diameter of furnace, and the end of grate bar should be not less than 10 inches from end of furnace.

That good iron tubes are most suitable and have less risk of leaky joints in tube plate.

That retarders are essential and necessary under forced draft for 2.5-inch tubes and upwards.

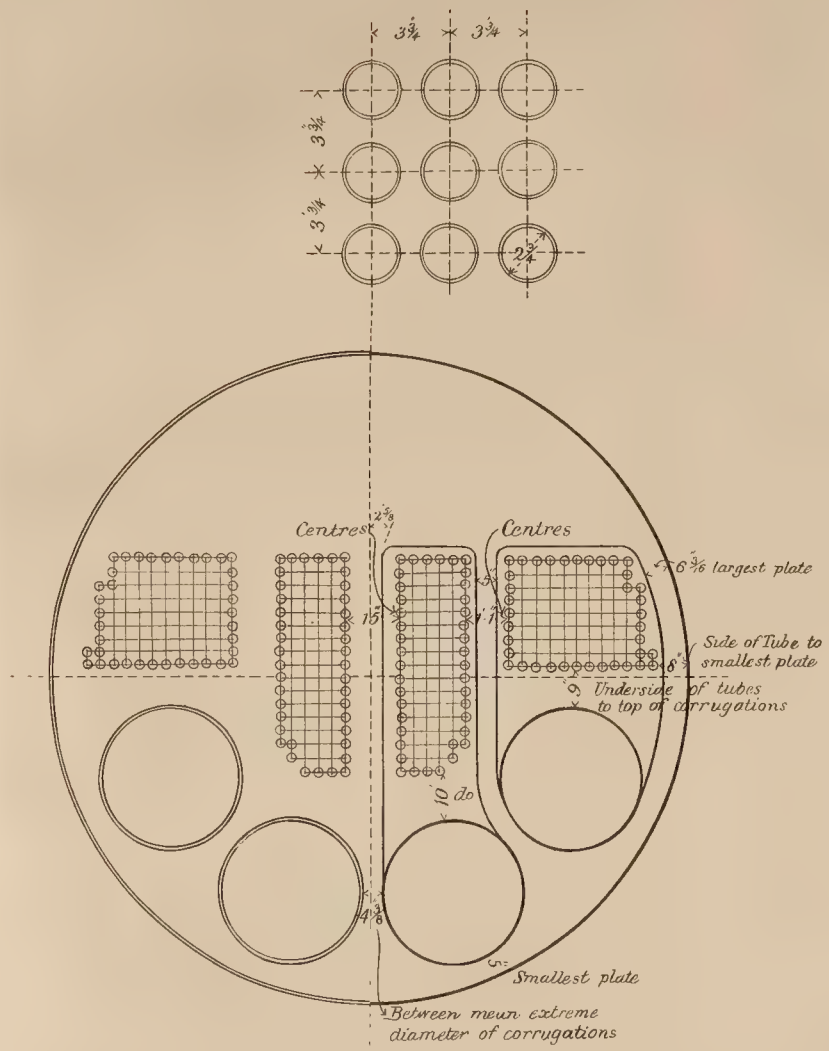
That the closed ash pit system using heated air above and below furnace bar has additional advantages besides those mentioned, viz, less risk of leakage, easier worked, and more economical, and that the cold-air pressures where closed stokeholds are used should be considerably reduced, they being liable to severely affect the intensely-heated surfaces of combustion chambers and tube plates.

That where tubulous boilers are used the feeding arrangements should be of a thoroughly reliable character.

G. W. MANUEL.

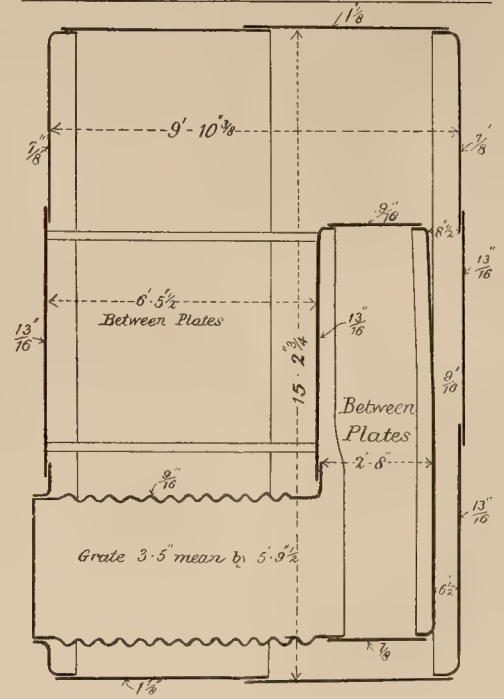
H. M. S. "MONARCH".

Scale 1/4 = One foot.



PARTICULARS OF 8 BOILERS

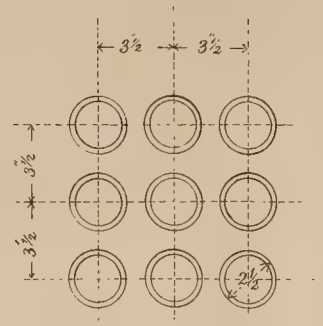
Heating Surface in Tubes	14770	Sq.r feet.
do do Furnaces &c.	3720	do
Total heating surface	18490	do
Area of Fire Grate	632·96	do
Area of through tubes	94.4	do
Diameter of Tubes		2 3/4"

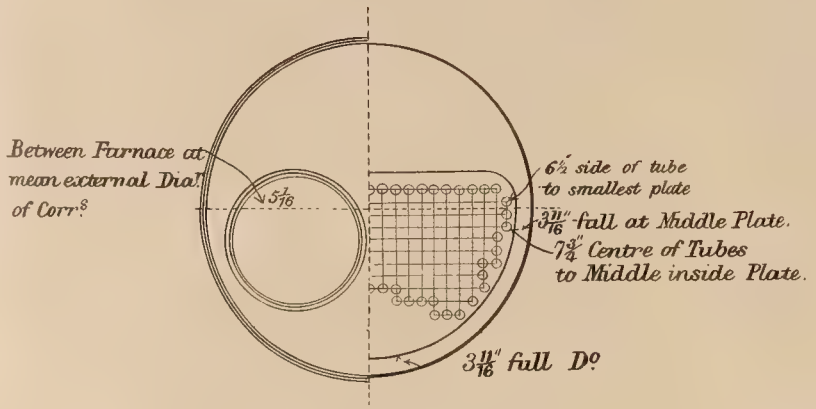


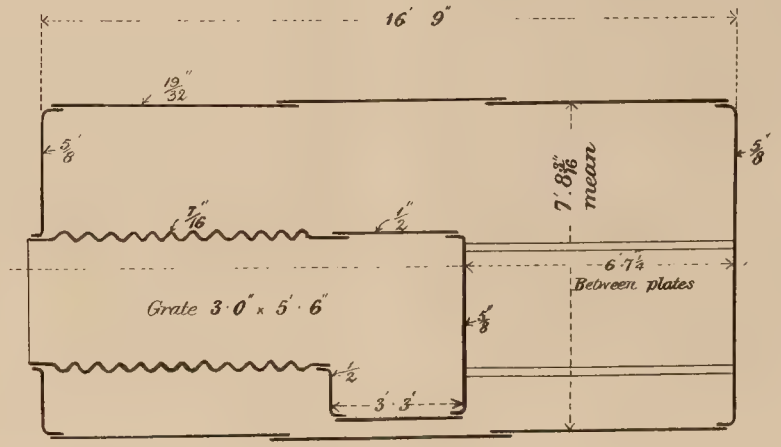
H. M. S. "THRUSH".

Scale ¼ inch = 1 foot.

Boilers Nº	2	
Tubes Nº	422	
Tube surface	1824	Sq. ft
Total heating surface	2106	do.
Grate surface	32·5	do.
Diameter of Tubes	2½"	





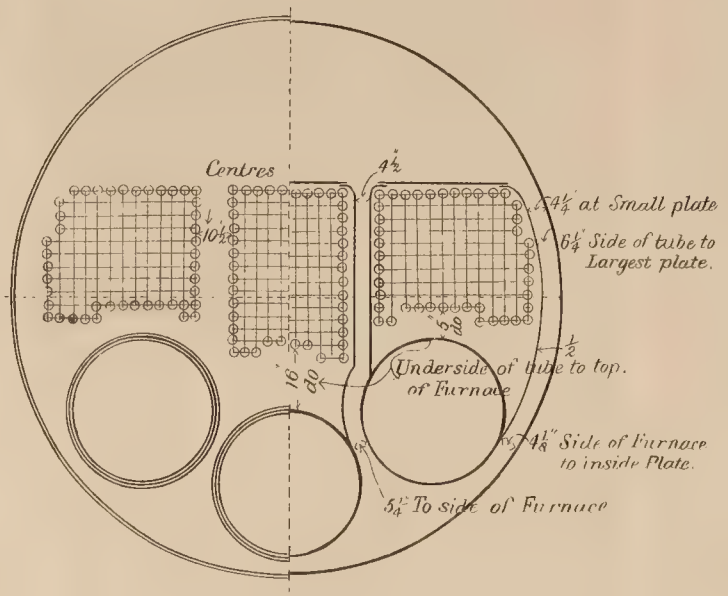


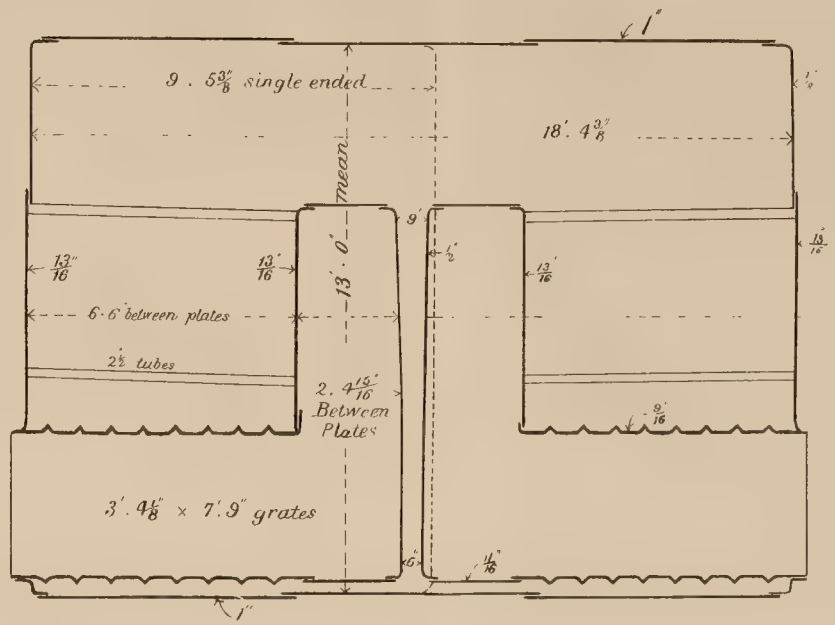
H. M. S. "SYBILLE".

Scale ¼ inch = 1 foot.

No. of Boilers, 3 double, 2 single ended

Heating surface ... 6057 sq. ft.
Grate surface ... 234 do
Diameter of Tubes ... 2½"

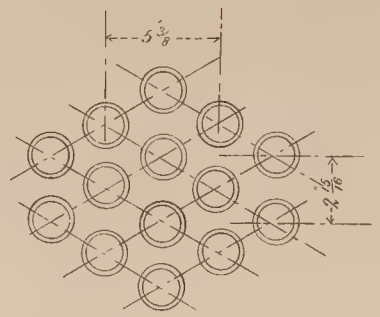


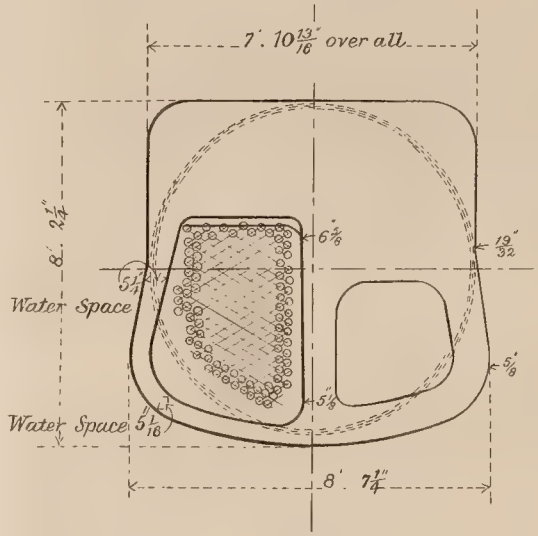


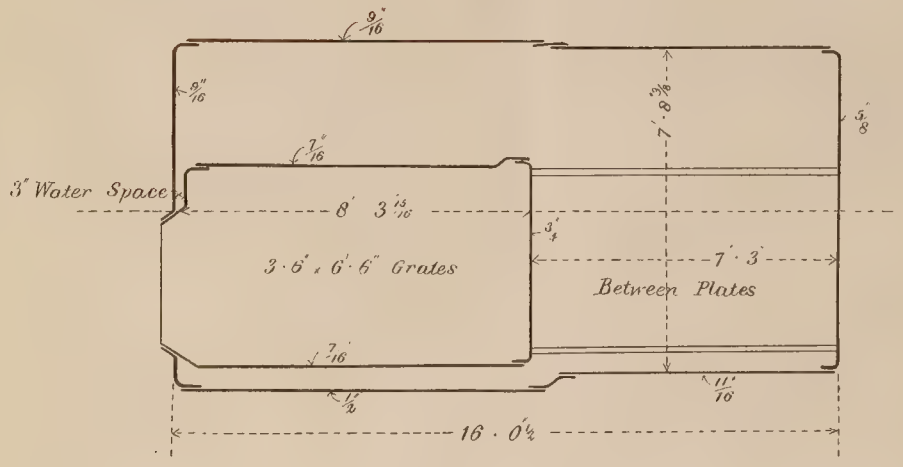
H. M. S. "JASON".

Scale ¼ inch = 1 foot.

Boilers	4 No.
Tubes No.	1448
,, diameter	2"
,, surface	5297
Total surface	6388
Grate surface	472



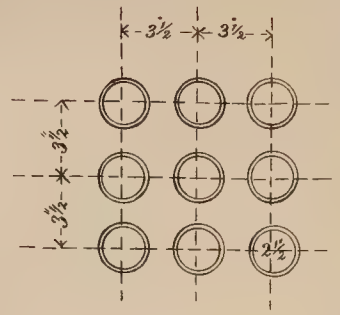


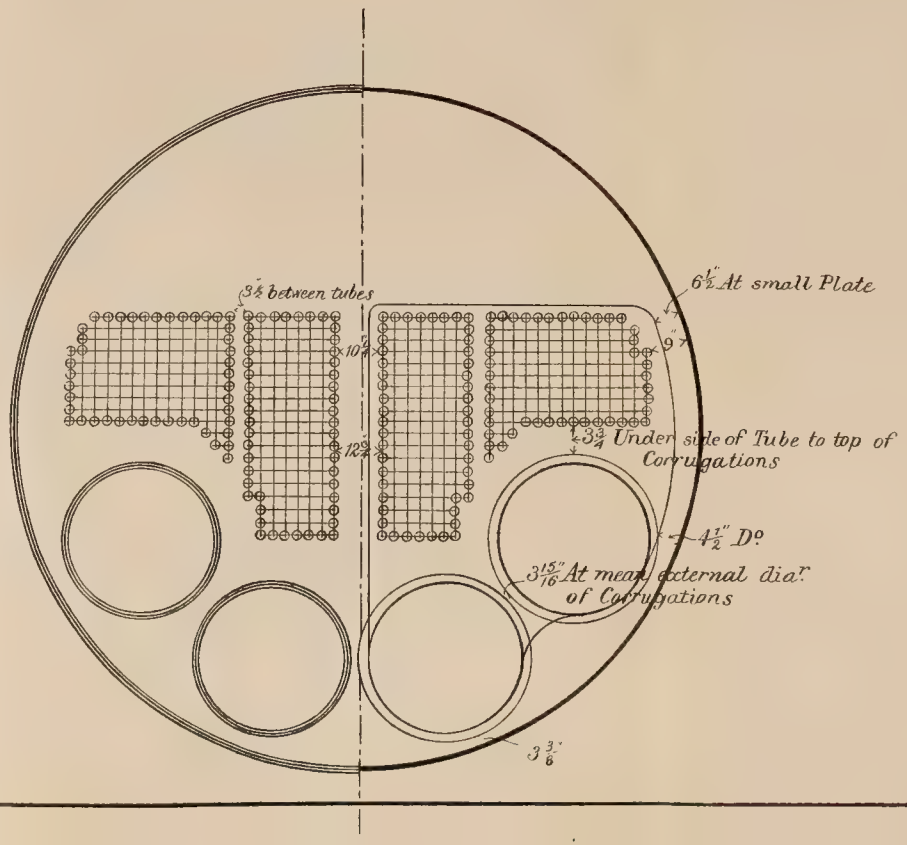


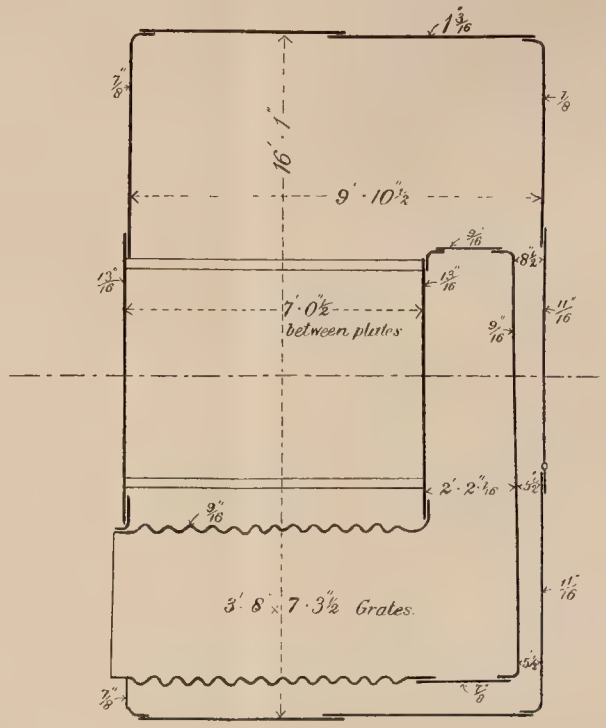
H. M. S. "CRESCENT".

Scale ¼ inch = 1 foot.

Boilers 8
Tube surface 21448
Total 24784
Grate surface 855
Tubes diameter 2½

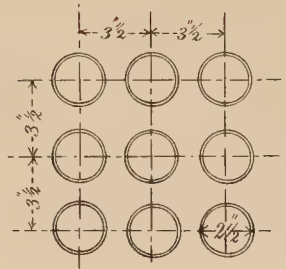






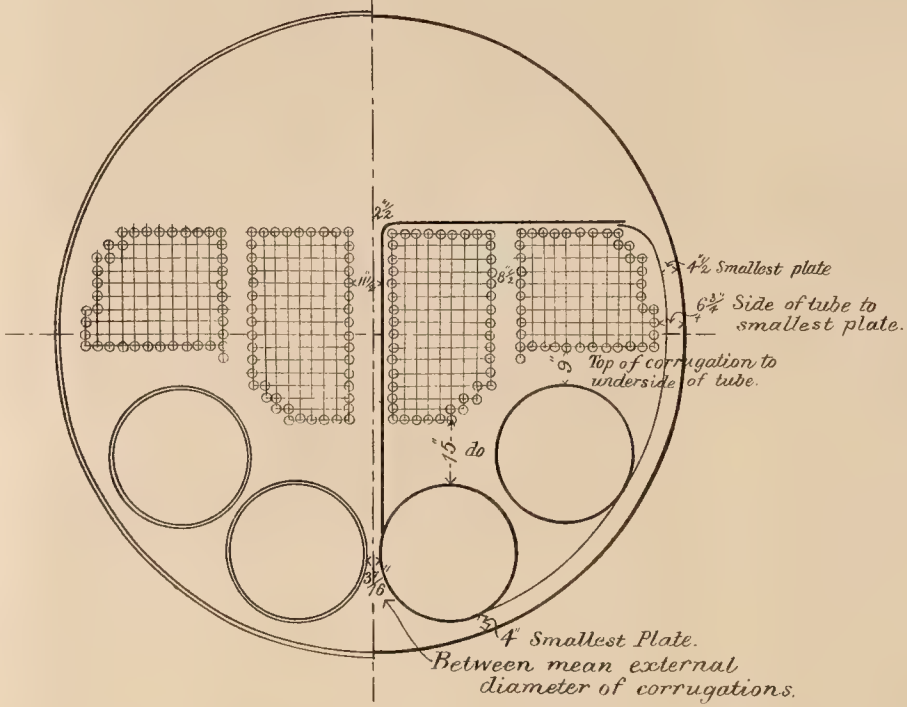
H. M. S. "ROYAL SOVEREIGN".

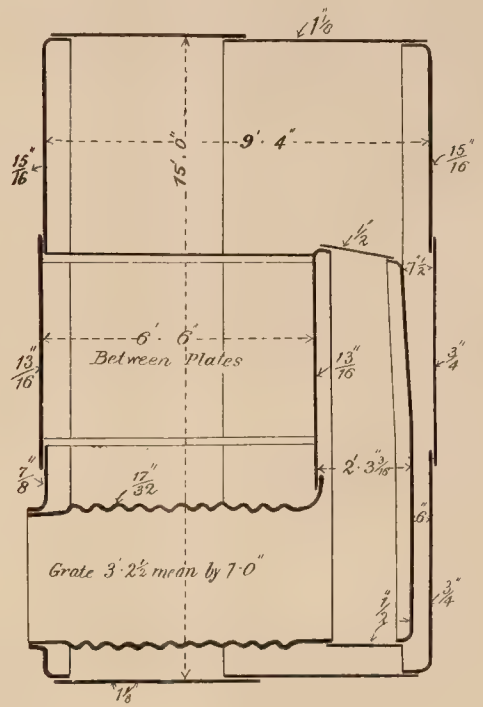
Scale ¼ — One foot.



PARTICULARS FOR 8 BOILERS.

Heating Surface in Tubes	17016	Sq^r ft
do do do Furnaces &c	3018	do
Total Heating Surface	20034	do
Grate Surface	718·6	Sq^r ft
Area through tubes	91·6	do
Diameter of tubes	2½	





H. M. S. "EDGAR."

Scale 1/4" = One foot.

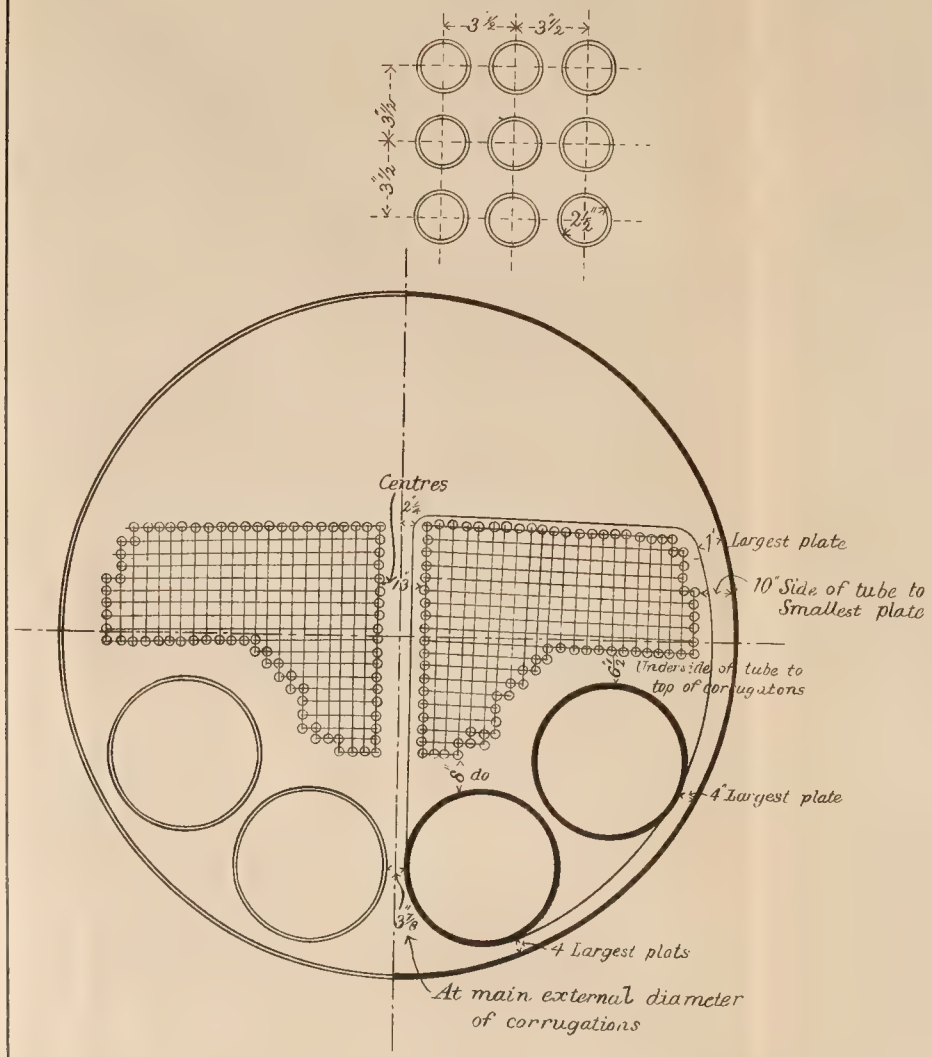
PARTICULARS FOR 4 BOILERS.

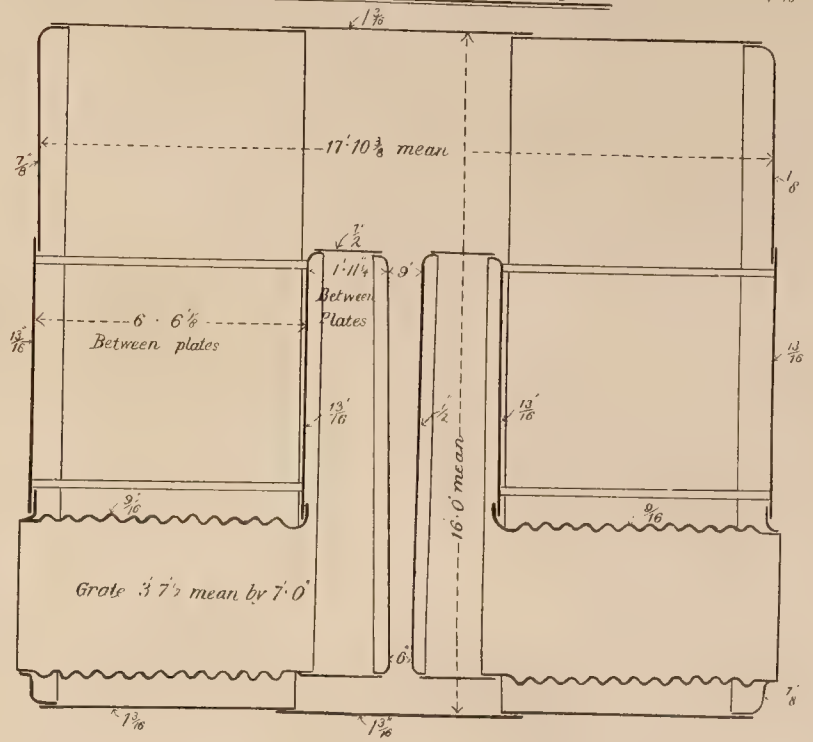
Heating Surface in Tubes	20108	Sq. ft.
,, ,, Furnaces &c	3160	
Total	23268	
Total Heating Surface for all boilers	24879	Sq. ft.
do Grate do do	868	do
Diameter of tubes 2 1/2".		

1 AUXILIARY BOILER.

do.	1408	Sq. ft.
do.	203	
do.	1611	

Mean Dia. of Aux. Boiler 12'·11"
,, ,, Length do. 9'·1 3/16





VIII.

THE QUALITIES AND PERFORMANCES OF RECENT FIRST-CLASS BATTLE SHIPS.

By W. H. White, Esq., C. B., LL. D., F. R. S.,

Assistant Controller of the Navy and Director of Naval Construction.

[Read at the thirty-fifth session of the Institution of Naval Architects, March 14, 1894.]

Five years ago I read before this institution a paper "On the designs for the new battle ships,"* which were then about to be laid down under the provisions of the naval defense act. Considerable public interest was shown in that paper, and in the discussion which followed, as was natural under the circumstances. Eight ships were to be built exceeding in dimensions any vessels previously constructed for the Royal Navy, and there were differences of opinion respecting the features of offense and defense embodied in the designs, as well as the policy of building vessels of such large dimensions and cost.

It is not my intention in the present communication to revive past controversies. The ships have been built; five of them are already in commission, one has been on active service since May, 1892, and the remaining three will be ready for service this month, when the five years end which were contemplated in the act of 1889. My wish is to place before the institution certain facts of professional interest in relation to the qualities and performances of the completed ships, and incidentally to compare the intentions of the designs with results obtained in the finished ships.

Seven of the ships are of the barbette type, with high free board throughout the length, carrying their 67-ton guns about 23 feet above water. The *Royal Sovereign* is the typical vessel in this group which will be most frequently mentioned, as she was first completed, and has been nearly two years in commission. Two others of the class were built in the dockyards and four by private firms. The machinery for the three dockyard ships was supplied by one firm. For the contract-built ships the firms supplied machinery as well as ships. One design

* *See* p. 97, General Information Series, No. VIII.

and specification served for the seven vessels so far as hull and fittings were concerned. For propelling machinery there were four designs, all practically governed by the same conditions for weight, space, and development of power on the contractors' trials.

The eighth ship (the *Hood*) is of the turret type, with moderate free board at the ends, over which the heavy guns deliver their fire. Those guns are about 17 feet above water. In the remaining features the *Hood* resembles the barbette ships, and her machinery was supplied by the same firm which undertook the corresponding work for the other dockyard-built ships.

Without further preface I will pass on to a statement of facts in regard to the ships as completed.

(1) DRAUGHT AND TRIM.

The designed mean draught, with all authorized weights and 900 tons of coal on board, was 27 feet 6 inches; the designed trim was 1 foot by the stern. A "board margin," or unappropriated weight, of about 500 tons was included in the load, to be carried at the designed draught. During construction various additions were made to the hull, equipment, and machinery, amounting in the aggregate to about 250 tons, the corresponding weight, with board approval, being taken out of the margin.

When the *Royal Sovereign* was completed a careful investigation was made, and it was found that at the designed mean draught she could carry 1,100 tons of coal, with all other authorized weights on board. In other words, the intentions of the design were fully realized, and 1,100 tons of coal could be carried, instead of 900 tons, on the specified draught. The ship in this condition was also to her designed trim.

Similar results have been obtained in the sister ships built in the dockyards. As might be anticipated, there are some differences in weight between the sister ships built in different yards and engined by different firms, but in no case is there any departure worth mentioning from the intentions of the design as regards draught and trim.

This is very satisfactory, having regard to the great sizes of the ships and their many novel features. In the completed ships certain additions have been made to the complements and consumable stores, as originally proposed. For example, the coal supply at normal draught was first fixed at 900 tons, with a bunker capacity of about 1,100 tons. The "wing spaces" abreast the bunkers proper were so constructed that they could be used as "reserve bunkers" if occasion arose, but it was not then contemplated to fill these spaces ordinarily. After experience in the *Royal Sovereign* it has been decided to carry the full weight of coal when leaving port, so that about 1,450 tons of coal are available. Of course the draught at starting is correspondingly increased.

Another alteration in practice subsequent to the design is the introduction of "reserves of feed water" for the boilers. Certain compart-

ments in the double bottom have been utilized for the purpose, and from 130 tons to 160 tons of fresh water are carried at starting. In addition the vessels have powerful evaporating plant.

For each additional inch immersion in these ships at load draught the increased displacement is about 55 tons, so that the extra coal and fresh water involves about one foot increase in draught. With their considerable free board and reserve of buoyancy, this is of no importance, and in their fully laden condition, with bunkers full, the defensive powers are greatly increased.

(2) STABILITY: METACENTRIC HEIGHT.

The determination of appropriate conditions of stability for these large ships was a matter of the most anxious consideration during the preparation of the designs.

One had to deal with circumstances in many ways unprecedented, particularly in regard to the loads of armor and armament, and the heights of the heavy guns and their protecting barbettes. It was recognized that these weights and their distribution would give the ships unusually large "moments of inertia," thus tending to long periods of oscillation, even if a good "metacentric height" was provided.

In regard to the metacentric height, it had to be kept in view that provision must be made not merely for possible variations in stiffness occurring on service and for sufficient "stiffness" when rapidly manœuvring, but for reductions in stiffness arising from damage in action. Here entered the consideration of the system of hull armor adopted, which gave a much greater *protected area* on the broadside—including the water-line belt and the lightly armored citadel standing on the belt deck—than had been possessed by many preceding classes in the Royal Navy, or was proposed for the most recent battle ships in some foreign fleets.

An unduly large metacentric height was undesirable, of course, tending to lessen the period of oscillation and to produce unsteadiness of platform under ordinary conditions at sea. A small metacentric height, while it would have lengthened the period and conduced to steadiness, might have involved a lack of stiffness for rapid manœuvring of the ships, or for training their heavy guns on one broadside. If reduction in metacentric height had been carried too far there would have been an undue reduction in the margin for possible damage in action. In existing ships examples are to be found of the evils attaching to either of these extremes in metacentric heights.

Moreover, I had to deal with an "unappropriated weight" of over 500 tons, and it was quite uncertain in what vertical position this might finally be placed, but judging by past experience, the probability was it would be added in *upper weights* of additional armor or armament, boats, and equipment.

Finally, I decided to aim at a metacentric height of about 3.5 feet for

the barbette ships when in normal load condition at the mean draught of 27.5 feet with 900 tons of coal on board. Past experience has shown that in ships of much less size and inertia an excellent combination of stiffness and steadiness had been obtained by the adoption of metacentric heights varying from 2.75 to 3.5 feet. In the new ships, having regard to their greater size and inertia, it was obvious that with a metacentric height of 3.5 feet the period of oscillation should be at least as great as and would possibly exceed the corresponding periods for their predecessors, whose reputation for steadiness was so great. The *Hercules*, *Sultan*, *Inconstant*, *Monarch*, and *Invincible* were among the vessels considered, as well as some foreign ships with equal reputations for steadiness at sea.

The loads of consumable stores in the new ships were so considerable that special care was necessary in disposing them, so that the variations in trim and stiffness produced by the consumption of these stores might be minimized. The range of draught between the deep-load condition and the ordinary light condition is 3 feet, corresponding to a change of nearly 2,000 tons in displacement. By suitable arrangements it was made possible for the ships to pass from the normal condition to the extreme light condition with practically no change in metacentric height.

When the full weight of coal (1,450 tons) is carried, since the reserve wing bunkers are low down, the metacentric height is increased to about 3.75 feet. The addition of the reserve feed in the lower compartments of the double bottom (made as explained above subsequently to the date of the design), involves a further increase in stiffness, bringing the metacentric height up to 4 feet, when wing bunkers, as well as ordinary bunkers, are full. This maximum stiffness may be decreased, of course, as coal and fresh water are consumed. It is interesting to add that it equals the metacentric height of the *Minotaur* class, which have good reputations for behavior at sea and are of much less inertia.

The practical constancy in stiffness obtained in the *Royal Sovereign* class, apart from reserve bunkers and feed-water, is in marked contrast to what was formerly common in armored ships where the coal was carried low down. For example, in the *Hercules* the metacentric height varied from 1.9 feet when light to 2.7 feet when fully laden, and in the *Devastation* the corresponding variation was from 2.5 to 3.7 feet.

Inclining experiments were made on the *Royal Sovereign* and the *Ramillies* (contract built) to check the design calculations. In the *Royal Sovereign* the actual position of the center of gravity was found to be 0.15 foot (1.8 inches) below the calculated position. In the *Ramillies*, owing to heavier machinery, it was about 4 inches below the calculated position. This close agreement between estimated and actual position was most satisfactory, and it was decided to be unnecessary to incline any more of the barbette ships. The turret ship *Hood* was also inclined with satisfactory results.

Members of the institution will understand that the satisfactory solution of this problem was not an easy matter. On all sides there were limiting conditions. The features of armor, armament, freeboard, and height of guns decided upon for the class practically regulated the distribution of the principal weights in a vertical sense and governed the vertical position of the center of gravity. The dimensions and forms of existing docks had to be considered; beam and draught could not be permitted to exceed certain maximum values. For manœuvring purposes the length had to be kept within reasonable limits. Stability had to be secured in association with a form adapted for high speed. This, I am happy to say, has been accomplished.

Some critics of war-ship designs entirely fail to recognize the part which stability plays in the selection of forms and proportions. They do not appreciate the radically different vertical distribution of weights in war ships as compared with merchant ships. Consequently they suggest the adoption of cross sectional forms and proportions of beam to draught and depth which would utterly fail to provide sufficient stiffness in war ships. Should effect ever be given to their views in actual ships, the result would be disastrous. There is, however, no risk in that direction, for closer scrutiny and exact calculation would disclose the danger.

There is usually behind these suggestions some idea of possible advantage to be gained in a particular direction. For example, a favorite view is that a flatter floor, sharper bilge, and nearly vertical side above the bilge would give greater displacement, in proportion to wetted surface, than the rounder bilge usual in war ships. This is quite true. Further, I have seen it stated that the alternative form would increase resistance to rolling, and give greater steadiness than the actual sectional form of our battleships. This is a matter of opinion. I will not enter upon its discussion now, but will only remark that, in my judgment, an altogether exaggerated value is attached in some quarters to the influence of sectional form in the central portions of the length upon rolling. One of the roundest forms of midship section ever adopted is that of the *Sultan*, and she has proved herself one of the steadiest ships afloat. Moreover, ease of rolling motion is a matter that must not be ignored, and in that respect the rounder form has distinct advantages. What is most important to note, however, is that such changes in cross sectional form lower the metacenter and diminish stability.

For purposes of information only, fig. 1 has been drawn, showing the comparative forms of midship section in the *Royal Sovereign*, a large ocean steamer of high speed, and the *Sultan*.

(3) CURVES OF STATICAL STABILITY.

In fig. 2 are given the curves of stability for the *Royal Sovereign* in various conditions. They are of an entirely satisfactory character. The maximum righting moment occurs at an inclination to the vertical

of 37 degrees; the maximum value of the arm of the righting couple is 2.33 feet and the range of stability is over 60 degrees.

Apart from the heave and impulse of the sea, the only inclining forces to which these ships, which have no sails, can be subjected are those when the vessels are turning rapidly and those arising from wind pressure. Neither are of any practical importance. Turning trials show the ships to heel very little. If a wind having a velocity of seventy-five miles an hour acted directly on the whole broadside, the angle of steady heel would not exceed four degrees, and wouldprobably be less.

Figs. 3 and 4 contain curves of stability for two typical ships which have had long and successful experience at sea. These afford an interesting comparison with fig. 2.

Fig. 3 shows the curves for the *Monarch* as she has hitherto served, with good sail power supplementing steam. It is interesting to note the diminution of stability in the light condition. Her sail equipment, of course, involved much more serious demands upon her stability than would have been made had sails been absent. But that matter was so fully discussed for the *Monarch* after the loss of the *Captain* that further remarks are unnecessary.

Fig. 4 shows the corresponding curves for the *Devastation* class of the Royal Navy. These vessels have no sails. Here the moderate freeboard, when fully laden, tends to lessened stability. As the ship lightens, although there is a loss of metacentric height, the gain in freeboard nearly counterbalances it.

Fig. 5 has been constructed for the load conditions of the *Royal Sovereign*, *Monarch*, and *Devastation*, the ordinates representing righting moments (not arms of righting couples). Here the greater weight of the *Royal Sovereign* tells as compared with the other two ships.

Fig. 6 has been constructed for the light conditions of the three ships, also to show righting moments.

As against external forces, such as wind pressure, figs. 5 and 6 are useful means of comparison. Under wave impulse figs. 2–4 are to be preferred.

(4) PERIOD OF OSCILLATION.

No rolling experiments in still water have yet been made on the *Royal Sovereign* class. From observations at sea, however, it appears that the period for a complete oscillation (double swing) is from 15 to 16 seconds. The time for a single swing—port to starboard, or vice versa—is 7.5 to 8 seconds. Variations in stiffness, due to alterations in lading, of course, affect the period; but with normal weights, and 3.5 feet metacentric, height, the period of oscillation is about 8 seconds. As above stated, this result was anticipated at the time the designs were prepared, and it brings the *Royal Sovereign* class, so far as period is concerned, into practical agreement with a number of ships which have

great reputations for steadiness. Most of these ships have smaller metacentric heights than the *Royal Sovereign*, but they are also inferior in weight and moment of inertia.

Some persons, in discussing the behavior of the *Royal Sovereign* class, have dwelt upon their relatively large metacentric heights, but failed to remark their great moments of inertia. Both are counted into the period of oscillation, and that is the best standard of comparison. The reasons for the selection of the metacentric height actually possessed by the *Royal Sovereign* class have been stated above.

(5) BILGE KEELS.

In this connection reference may be made to the reasons which led to the decision not to fit bilge keels to the *Royal Sovereign* class during construction. No one has more strenuously urged the utility of bilge keels than myself. But while it is undoubted that they can never do harm, and in many cases may do great good in limiting rolling, their influence varies under different circumstances. In small ships of quick period, and in ships of moderate weight and moment of inertia, they are likely to prove most beneficial. In slow-moving ships of great inertia the influence of bilge keels must clearly be less felt and may be very small. That influence depends upon the area of the keels, their radial distance from the axis of rotation, and their rate of motion through the water, which rate is governed by the arc of oscillation, and the period of the oscillation. Since, within considerable limits of oscillation, ships are practically isochronous in their motions, the mean rate of motion of bilge keels through the water varies with the arc of oscillation. In other words, fluid resistance to the motion of the bilge keels has a small value and moment about the axis of rotation in a slow-moving ship until considerable angles of oscillation are reached.

Moreover, with a given moment about the axis of rotation of fluid resistance to the motion of bilge keels, the check put upon the rolling of a ship to which they are attached depends upon the weight, the stiffness, and the moment of inertia of the ship. It may happen, therefore, in large slow-moving ships that the influence of the largest practicable bilge keels will be scarcely felt until considerable angles of rolling are reached.

This appeared to be the case in the *Royal Sovereign* class, and it was, therefore, decided not to fit bilge keels at the outset, until experience had been gained at sea with the ships. In thus deciding, the fact was kept in view that two vessels of exceptional steadiness, the *Hercules* and the *Sultan*, were practically without bilge keels, the side keels being very shallow in depth. Moreover, it was obvious that if bilge keels could be omitted it would greatly facilitate docking the ships.

As an experiment, bilge keels have now been fitted to the *Repulse*, and she will be tried in company with other ships of the class. Provided that these trials are made under the same conditions of lading in all

the ships, the results will be very valuable. Should the keels prove sensibly advantageous, they can easily be added to the sister ships.

It is unnecessary to repeat what has been said above with reference to the supposed influence of cross-sectional forms upon resistance to rolling. The analysis of a large number of rolling experiments on ships of very different cross-sectional form has shown that the portion of the resistance contributed by the midship parts of the length is small when compared with those portions of the resistance due to the deadwoods and flat surfaces, while surface disturbance greatly exceeds both of these factors.

One remark may be added. In recent years the battle ships of the Royal Navy have, for the most part, been constructed with low ends. Hence moderate angles of rolling immerse the edges of the low decks and greatly increase resistance to rolling. There can be no question but that this deck resistance is a valuable feature in limiting oscillation under many circumstances.

In high-free-board vessels of the *Royal Sovereign* class there is no corresponding element of resistance to rolling. On the other hand, the high free board and great height of guns increases fighting efficiency, the power of maintaining speed in rough water, and comfort to all on board. Under circumstances when the low-free-board ships have to be battened down, or when they can fight their guns with difficulty, the high-free-board ships suffer from no similar drawbacks.

(6) BEHAVIOR AT SEA.

Experience at sea with the new battle ships has been very limited, except in the case of the *Royal Sovereign*, which was commissioned in May, 1892, as flagship of the Channel Squadron. The sister ships, *Empress of India* and *Resolution*, were commissioned for service with that squadron in September and December last. The turret ship *Hood* joined the Mediterranean fleet in June, 1893, and the *Ramillies* became the flagship on that station in October; but except on the passage out these ships have not had experience in the Atlantic. It is to the *Royal Sovereign*, therefore, that one must turn for information as to behavior over any considerable period. Apart from long-continued experience under various conditions of wind and sea, no fair appreciation is possible of the true qualities of any ship or class. I propose, therefore, to briefly summarize the facts for the *Royal Sovereign*, and subsequently to deal with the case of the *Resolution*, which was so much before the public in January last.

It will be convenient here to recapitulate the broad conclusions in regard to the rolling of ships, which have been established by theoretical investigation, and confirmed by experiment and observation during the thirty-four years that have elapsed since the late Mr. W. Froude brought his new theory before this institution.

First. The behavior of a ship depends chiefly upon the ratio of her

period of oscillation to the apparent period of the waves which produce rolling.

Second. The slope of the waves, their ratio of height to length, is an important factor in the rate of accumulation of rolling and its maximum amplitude.

Third. The resistance offered by water to the rolling motions of ships is most influential in limiting rolling, and any means available for increasing that resistance and the "rate of extinction" of rolling must be beneficial.

Fourth. For any ship the condition tending to produce the heaviest rolling is that when the waves pass her at a rate which synchronizes with her natural period of oscillation in still water. Apart from the action of resistance, the successive impulses of a regular series of synchronizing waves would increase the amplitude of the oscillations so rapidly that any ship must be capsized in a very short time.

Fifth. Every ship, no matter what her size and period of oscillation, is liable to this condition of synchronism. It may occur with a beam sea of period identical with her own, or it may result from the course and speed being such as to produce synchronism with waves of dissimilar period. In fact, allowing for the infinitely varied conditions of sea necessarily encountered, no ship can altogether escape from heavy rolling.

Sixth. Experience has confirmed the deduction from mathematical investigation that ships which are slowest in their still-water oscillations, as a rule, are steadiest at sea.

Seventh. For slow-moving ships, of long still-water periods, the condition of synchronism is sometimes reached in a long and very low swell, with practically no wind. This swell results from waves which have traveled long distances, from the storm region in which they were formed, and in transit have been greatly degraded in height, while retaining considerable length and period.

Eighth. When rolling is set up in ships by the passage of waves, it may be anticipated that the heavier ships, with greater moments of inertia, will accumulate the largest angles of oscillation.

This is readily understood, apart from mathematical demonstration. Each wave as it passes tends to increase the oscillation, and the increment is dependent upon the wave-slope, while it is little influenced by the size or weight of the ship, if the waves are of great length in proportion to the dimension of the ship (usually her breadth) presented to the wave advance. On the other hand, the effect of water-resistance in limiting oscillation depends, as previously explained, upon the relation of its moment about the axis of rotation to the righting moment and moment of inertia of the ship. That is to say, the moment of the water-resistance becomes relatively less as the weights and inertia of ships increase, and consequently in two ships of identical period exposed to the same waves (say, synchronizing in period or nearly so) the larger ship of greater inertia will reach larger angles of oscillation.

Bearing in mind these conclusions from long experience, we may pass to the summary of facts respecting the actual behavior at sea of the *Royal Sovereign.*

During the first eight months the ship was on service there was no report in regard to her rolling, and the only statement in regard to her behavior was to the effect that off the coast of Ireland, in the Atlantic swell, she had compared very favorably with vessels of the *Admiral* class.

In January, 1893, during a passage from Plymouth to Vigo, the ship encountered a long, low swell, which set her rolling; and in the cruise which followed, to Madeira and back, very similar conditions prevailed. The striking feature in this case, which naturally attracted great attention, was that so large a ship should be set rolling by what would ordinarily be treated as a smooth sea, when smaller ships of less period were practically unaffected. Careful observations were made of the character of the swell which produced these results. It was found that with lengths varying from 450 feet to 700 feet were associated heights varying from 6 to 12 feet, and it became obvious that these waves were so related in period to the period of the *Royal Sovereign* that rolling necessarily resulted, while ships of less period remained steady. This was no new phenomenon, as I will explain hereafter.

The actual angles of rolling on this occasion were not considerable, as the following summary of observations will show:

Inclinations on each side of vertical.

	Mean.	Maximum.
	Degrees.	*Degrees.*
January 18, 1893	4.6	9
January 19, 1893	8.5	13.5
January 20, 1893	2	4.5
February 11, 1893	8.5	16
February 12, 1893	7	11

It will be understood, of course, that the maximum angles of inclination only occurred at intervals, the rolling passing through "phases;" mean inclinations are the fairer measures of average behavior.

After this cruise under the conditions described no further reports of rolling were received until the end of December, 1893. The squadron was then proceeding from Gibraltar to Arosa Bay, and encountered a heavy swell, in perfectly fine weather with an otherwise smooth sea. The apparent period of the waves was found to vary from 13 to 15 seconds; the period of oscillation of the *Royal Sovereign* class (double-swing) being 15 to 16 seconds. The lengths were estimated at 650 to 960 feet, and the heights at 10 to 15 feet. In this case, therefore, there was a close approach to synchronism in the periods of the waves and

the big ships, the *Empress of India* being in company; while the quicker-moving ships were more advantageously situated. In the following table are given a set of simultaneous observations for the ships of the squadron:

Inclinations on each side of the vertical.

	Mean.	Maximum.
	Degrees.	*Degrees.*
Royal Sovereign	7	11.5
Empress of India	5.9	10.5
Immortalité	2.8	5
Narcissus	3	7
Bellona	6.2	13.2

The *Rodney* was in company but did not take simultaneous observations on the occasion described in the table.

Taking all the observations made at various times during this day, and disregarding changes which may have occurred in the course and speeds of the ships, or changes in the state of the sea, the following summary represents the facts:

Mean inclination on each side of the vertical

	Degrees.		Degrees.
Royal Sovereign	6.8	Narcissus	3.3
Empress of India	9.4	Rodney	5.8
Immortalité	3	Bellona	6.1

In order to illustrate the general character of the motion of the large ships, the gradual increase in amplitude, attainment of a maximum inclination, and subsequent gradual decrease, fig. 11 has been prepared from a series of actual observations.

One feature in the accumulation of rolling under the trying conditions of synchronism is the apparent *suddenness* with which comparatively large angles of inclination may be accumulated. Here, again, theoretical investigation anticipates observation. Apart from the action of resistance, the passage of each synchronising wave should add an angle equal to about three times its maximum slope to the range of oscillation. In the long, low swell which synchronised with the *Royal Sovereign* class, the maximum slope was about 3 degrees only, corresponding to an increment in range, apart from resistance, of more than 9 degrees for each wave, apart from resistance. There would be four waves passing in a minute; and it is easy to understand, therefore, in how short a time considerable angles of rolling may be reached, especially in a slow-moving ship, where resistance acquires no great moment until there is a good swing.

When the *Royal Sovereign* and *Empress of India* were placed beam on to the swell, and a series of nearly regular waves of synchronising

periods passed the ships, much larger inclinations were reached at times than are shown in the foregoing tables. The maximum inclinations recorded under these very trying conditions were about 25 to 30 degrees, which is undoubtedly heavy rolling, and has naturally been made the subject of adverse remarks.

It may be well to explain, therefore, that this kind of behavior has been experienced long ago, under very similar circumstances, in vessels having unsurpassed reputations for average steadiness, and about the same periods of oscillation as the *Royal Sovereign* class. In this connection I will venture to quote a passage from my "Naval Architecture," published nearly twenty years ago.

No feature in the behavior of ships is better established than that heavy rolling results from equality, or approximate equality, of the period of the ship and the period of waves, even when the waves are very long in proportion to their height. Many facts might be cited in support of this statement, but a few must suffice. * * * Vessels of the *Prince Consort* class were made to roll very heavily by an almost imperceptible swell, the period of which just synchronised with that of the ships (for a double roll). On one occasion the *Achilles*, a vessel having a great reputation for steadiness, rolled more heavily off Portland in a dead calm than she did off the coast of Ireland in very heavy weather. Mr. Froude reports a very similar circumstance as having occurred (in the channel) during trials with the *Active*. And, lastly, during the cruise of the combined squadrons in 1871, when the *Monarch* far surpassed most of the ships present in steadiness in heavy weather, there was one occasion when, doubtless through the action of approximately synchronising periods, she rolled more heavily in a long swell than did the notoriously heavy rollers of the *Prince Consort* class.

The *Hercules*, as a rigged ship, was remarkable for average steadiness of platform. Yet on some occasions, in a swell very similar to that which set the *Royal Sovereign* class in motion, she rolled to angles of 25 and 30 degrees on each side of the vertical. Similar experience has been obtained with the *Inconstant* and other vessels.

These instances are not quoted for the purpose of diminishing in the least degree the important influence upon fighting efficiency of steadiness of platform in war ships. It is not a possibility, however, to secure absolute steadiness under all conditions of sea for the reasons given above. The designer, therefore, must fall back on experience, and endeavor to secure *average* steadiness. His aim is to give to a new design about the same period of oscillation as was possessed by ships of proved good behavior. In the design of the *Royal Sovereign* class, as already explained, it was intended to approximate to the period of ships like the *Hercules* and *Monarch*. This has been accomplished, and it is important to note that in the ships as they now go to sea, by additions of coal and feed-water, the stiffness has been increased, and period correspondingly quickened. With the weights on board originally contemplated as "normal," the period would be about 7 per cent greater than in the deep-laden ships. As they now have periods of about 15 seconds when deeply laden, this would mean an increase of about one second in the time for a double swing.

This may be thought a refinement by some persons, but it is by no means the case that such differences in period do not affect behavior. In fact, observations made in the *Royal Sovereign* class, with varying conditions of stowage of coal and feed water, show such changes in stiffness and period to have quite appreciable effects.

Small changes in course and speed relatively to synchronizing waves also produce marked results on rolling. As an illustration, I may take a recent observation made by the *Royal Sovereign*. With swell abeam, the mean inclination to the vertical was about 9 degrees and maximum (occasionally reached) 18 degrees. With the swell 2 points before the beam, the mean inclination was about 5.5 degrees and the maximum 10.5 degrees. With swell 4 points before the beam, the mean inclination was about 4 degrees and maximum 9.5 degrees.

Further reports on observations of rolling were made after the passage of the Channel Squadron from Vigo to Madeira in January last. There is no new feature requiring detailed notice. Throughout there was a long, low swell, or a confused sea. On the whole, the *Royal Sovereign* class rolled less than in the December cruise, the wave periods not approaching so closely to synchronism. An analysis of the figures shows that the mean inclinations to the vertical averaged about 6 degrees for the class. Inclinations exceeding 15 degrees are not reported for the *Empress of India* during the period of observations, and are only twice mentioned for the *Royal Sovereign* and three times for the *Resolution*. On one occasion the *Resolution* reached an inclination of about 31 degrees, and the *Royal Sovereign* on one occasion reached 21 degrees. These were altogether exceptional rolls, and must have resulted from some special condition of the sea at the time, although no details appear in the reports.

All the reports on the class speak of the rolling motion of the ships as remarkably easy, free from jerks, and with quick recovery from extreme inclinations. This was anticipated from their form, period of oscillation, and conditions of stability.

Summing up the facts, so far as they are in my possession, it appears that during the period of her service, now approaching two years, the *Royal Sovereign* has, on the whole, proved herself steady and well behaved at sea. The heaviest rolling of the class has occurred under the conditions of a long, low swell, synchronizing, or approximately synchronizing, with their period of oscillation. In this respect the class resembles the *Hercules*, *Monarch*, and other ships of remarkable average steadiness and about equal period. Under such circumstances, the great inertia of the *Royal Sovereign* class, inevitable with their offensive and defensive arrangements, occasionally tends to produce considerable angles of inclination. A very moderate change of course produces considerable reduction in rolling.

Unsteadiness of platform under these conditions is clearly a drawback. There is no question of danger arising, however, as is explained

hereafter. The edge of upper decks has been only just awash when the rolling has been heaviest in a long swell. Experiments are about to be made with bilge keels in one of the vessels, in order to determine whether the increase in resistance thus obtained will sensibly diminish rolling.

All past experience shows that ships having periods of 15 to 16 seconds for a double swing are, as a rule, exceptionally steady at sea. The *Royal Sovereign* class have about that period, and there is nothing whatever in their under-water form or stability to make their behavior differ from that of their equally slow-moving predecessors. Their greater inertia is the new and inevitable condition of the designs. Further experience is required to determine the relative steadiness of the class under average conditions of sea.

In concluding this section, I desire to place on record our great indebtedness to the naval officers serving in the *Royal Sovereign* class for the valuable observations they have made and recorded. Capt. Hammill, of the *Royal Sovereign*, deserves special thanks for the information he has afforded, as well as for many valuable suggestions. Having to go beyond precedent necessarily involves new conditions. Whatever care or skill may have been bestowed on a design, nothing but actual experience can show whether or not it is successful. Much as we have learned respecting the behavior of ships, there are still many obscure points, and in elucidating these, naval architects must depend upon naval officers for facts as to the conditions of sea and the performances of ships.

(7) BEHAVIOR OF THE *RESOLUTION* IN DECEMBER, 1893.

The case of the *Resolution* is quite distinct from that of the other ships of the class, and it has been so prominently before the public that I propose to state the facts briefly. It will be understood that a full discussion of the incident is not intended, nor, indeed, is it possible for one holding my official position to attempt it, for reasons that will be obvious.

The *Resolution*, a newly commissioned ship, left Plymouth at 2 p. m. on December 18 last, to join the Channel Squadron at Gibraltar. On December 23, at 9 a. m., she arrived at Queenstown. According to the newspaper accounts, the ship had been seriously strained in structure by heavy rolling, reaching to angles of 30 or 40 degrees from the vertical. Dangerous leaks had been developed, and she could only be kept afloat by continued pumping. Considerable repairs were said to be required, and it was alleged that she was in such a state that she could hardly proceed without risk as far as Plymouth or Portsmouth before being taken in hand. Graphic accounts followed of the terrible weather which had been encountered, of the unsatisfactory behavior of the ship, the great discomforts suffered by all on board, and the immense quantities of water which were said to have passed down into engine

rooms and stokeholds. In short, the impression was produced, and possibly still remains in many minds, that the *Resolution* had a narrow escape from disaster, and her behavior was considered the more unsatisfactory seeing that the torpedo gunboat *Gleaner*, which was in her company, had proceeded to her destination, while the big ship put back.

Now for the facts. It has been stated by the representative of the admiralty in the House of Commons that the captain of the *Resolution*, in the exercise of his undoubted discretion, put back to Queenstown because he considered it the wiser course, having regard to the possible continuance of bad weather, and the quantity of coal remaining on board.

The ship proceeded to Devonport, and a careful survey was made by the officers of Devonport dockyard, who had nothing whatever to do with the construction or fitting out of the *Resolution*. This survey established the entire absence of any working or weakness in her structure. Various fittings on or above the upper deck and outside the ship were damaged or washed away by the sea. The bridges, which are merely light superstructures at a considerable height above the shelter deck, showed some small signs of movement, but nothing of any importance. There were no serious leaks anywhere. One or two places were found where small fittings had been attached to the sides, and the rivets were not absolutely water-tight. A few local defects in the deck planks had permitted trivial leaks to occur here and there. Some small leakage also occurred at gun ports, deck pipes, and other openings provided with covers that had been thoroughly tested during construction, but were apparently not so well secured as they might have been when the storm was encountered. In dealing with such fittings, experience counts for much, and a newly commissioned ship is always at a disadvantage. Other fittings which were in place need not have been there under the circumstances, arrangements having been made for stowing them in safe positions at sea, or when bad weather was anticipated. The covers to the forward barbette gun wells were washed away by the sea, not because they were not strong enough, but because they were not properly secured; and this circumstance led to the entry of water through the barbette.

The best possible evidence to those conversant in such matters of the trivial and unimportant character of the defects arising from this experience of the *Resolution* is found in the fact that they were all made good—including repairs to damaged fittings and renewals of fittings lost—for the sum of £440 ($2,130).

There is no evidence that large quantities of water, much less dangerous quantities, passed into the interior. Before the hatches were battened down amidships a sea broke on board, and some water found its way down to the main deck and into the engine room, but this did not recur after the battening down. Discomfort there was, no doubt,

during the three days the ship was battling with the storm; but that is a common experience, and not peculiar to war ships. It has come to my knowledge that two large passenger steamers which were crossing the bay about the same time had a very similar experience, but they continued their voyages, and I have not seen any comments in the press in regard to their behavior. The storm was undoubtedly severe, and the sea was exceptionally high and steep for a considerable time.

After passing Ushant early on the morning of the 19th, the *Resolution* had a swell on the beam, which caused her to roll considerably. The wind, which was south at starting, veered during that morning to west, and then to northwest. She was kept on her course for seven or eight hours, until about 7 p. m. Two exceptionally heavy rolls then occurred, and the sea broke over the upper deck amidships. The hatches were not battened down at the time, and water passed through them on to the main deck and into the engine room, as above described. After this happened the ship was brought head to sea, gear secured, and battening down completed. She then resumed her course; but, as she again began to roll considerably, she was once more brought head to sea and there kept, steaming slowly. This happened about 9 p. m. on December 19.

The swell increased and the wind freshened during the night. By 8 a. m. on December 20, it was a whole gale, with tremendous squalls. Measurements of the waves were made that day with all the care possible under the circumstances. Accurate measurement, especially of length, was hardly possible. The wave heights were obtained by horizon observations, and are probably more nearly correct. Heights of 42 feet were observed from hollow to crest, and lengths of 300 feet from crest to crest. The exceptional steepness of these waves will appear from the fact that extensive observations have fixed the average height of large Atlantic storm waves at one-twentieth of the length, so that waves 42 feet high would be over 800 feet long. Similar observations give 15 feet as the average height for waves 300 feet long. No doubt in this instance, as in many others, where the wind has veered during a long-continued storm, there were independent series of waves running in different directions and superposed on one another, which would account for the height and steepness of the waves observed.

The ship was kept head to sea until 4 p. m. on December 21, when the swell had begun to drop somewhat, but was still from the northwest. Measurements of waves that morning showed heights of 26 to 30 feet, and lengths estimated at 280 feet, still a very steep and heavy swell. A northerly course was then shaped; and, as the swell decreased gradually during the night, on the morning of the 22d the ship proceeded to Queenstown. On arrival she had over 450 tons of coal on board, having left Plymouth with about 790 tons.

There are two stages to be considered in this narrative. First, that during which the ship was exposed for some hours to a swell abeam,

described as moderate, but said to produce occasional heavy rolling. This resembles the case above discussed for the *Royal Sovereign* class; and in his report the captain of the *Resolution* expressed the opinion that the cause of rolling was approximate synchronism between the period of the ship and that of the waves.

The second stage is that where the ship was kept head to the sea. Her behavior under these circumstances is reported to have been most satisfactory. She was very buoyant, rode well over the very heavy sea, and pitched easily. At times she rolled considerably, which is not remarkable when the state of the sea and its confused character are taken into account. It is reported also that under these conditions the oscillations were quite different from those which occurred when the swell was abeam. In the latter case the rolling gradually increased, reached a maximum, and then gradually diminished—completing a "phase," in fact, like that represented in fig 11. Head to sea the ship is stated to have "lurched" at once, or nearly so, to her maximum inclination, and then to have gradually lessened her swing in succeeding oscillations. This is what would be anticipated from the position she occupied in relation to the short, steep sea, and the pitching and 'scending motions impressed upon her. Under these circumstances there would necessarily be great variations in the distribution of the buoyancy as compared with still water, and considerable temporary reductions in transverse stability, which would account for the occasional heavy lurching. Moreover, there must have been very severe longitudinal bending moments on the structure, and it is most satisfactory to find that there was no indication whatever of working or weakness.

Another fact of great importance must be stated. There is no trustworthy evidence of the angles through which the *Resolution* rolled on this occasion. The only observations recorded were made with a short, quick-moving pendulum placed in the chart-house, at a height of 35 to 40 feet above water. I need not dwell upon the possible errors of pendulums so placed in a ship rolling among waves. Cases are on record where the indications of pendulums, similarly placed in ships of about the same period, have been *twice the true angles* of oscillation, observed simultaneously by trustworthy methods. In fact, no experienced naval officer trusts pendulum observations, spirit levels, or gravitational instruments of any kind for use at sea.

One can not fix precisely what was the actual error of the pendulum in the *Resolution*. But it is certain that its movements placed at such a height must have grossly exaggerated the rolling of the ship. When angles of inclination of 30 or 40 degrees are said to have been indicated by, or estimated from, the movements of the pendulum, the actual angles must have been much less, and may have been only half what was shown on the scale.

It is important to note also that, even had these great angles of inclination been reached, there would have been no reason for apprehension of danger to the ship. The curves of stability (fig. 2) show

that the maximum righting moment occurs at an inclination to the vertical of 37 degrees, and that instability is not reached until the inclination exceeds 60 degrees. There is a popular impression, no doubt, although an absolutely erroneous one, that if a ship is inclined past her angle of maximum stability, she will capsize. To this institution I need not explain that even in a ship with large sail power, and exposed to squalls of wind, there may be no danger in angles of inclination much exceeding that at which the righting moment reaches its maximum. But when, as in the case of the *Resolution*, there are no sails, and the inclining force of the wind on the broadside is relatively so small, there is a much greater margin of safety.

In fig. 7 a cross-section of the *Resolution* is given for an inclination, in still water, of 40 degrees to the vertical. At this inclination the righting moment for all practical purposes may be considered as maintaining its maximum, and has a value of more than 30,000 foot-tons. This is the greatest angle of roll which, by pendulum or estimate, has been attributed to the *Resolution*. For the reasons just stated it is practically certain it was never approached. Had it been approached the upper deck must have been invaded by the sea to a much greater extent than actually happened.

Among waves, the *rise of the sea*, as well as the rolling of the ship necessarily influences the amount of water which comes on to the deck. This fundamental truth is often overlooked, and in some discussions on the *Resolution's* behavior, this has been done. Simply to illustrate the well-known fact figs. 8 and 9 have been prepared. The latter shows the *Resolution* beam-on to trochoidal waves of the heights and lengths said to have been observed on December 20, but to which she was then kept bow-on. The maximum slope of the waves is 26 degrees, and an inclination to the vertical of 8 degrees would then immerse the top of the bulwarks. In this position the corresponding angle on the curve of stability for measuring the righting moment would, of course, be 34 degrees.

Fig. 8 shows the *Resolution* beam-on to an Atlantic storm wave 600 feet long and 30 feet high, the maximum slope being 9 degrees. Here an angle of inclination to the vertical of 25 degrees would bring the top of the bulwarks awash.

In practice, of course, waves have not the regular forms shown on the diagrams, nor are successive waves of identical size and height. The "rise of the sea" on occasional waves in a series often considerably exceeds the average rise, and in a confused sea formed by superposed series these variations in height are very striking. Even with my limited opportunities for studying wave phenomena, this has been much impressed on my mind, and experienced naval officers have frequently drawn attention to the same fact when the assumptions made in the mathematical theory of rolling have been explained to them.

Fig. 10 has been constructed on the hypothesis of two superposed series of waves, one 600 feet in length by 20 feet in height, and the other

300 by 20 feet in height. At certain times the ship on such a compound wave, if broadside on, might immerse her bulwarks at an inclination of 18 degrees. If end on, the wave crests passing rapidly, might also rise considerably above the bulwarks and come on to the upper deck.

The presence of water in considerable quantities, at times, on the upper deck of the *Resolution* can not, therefore, be regarded as any proof that the ship approached the angles of inclination indicated by the pendulum; much more moderate angles, under the circumstances described, would have produced this result.

It is undoubted that the ship at times rolled considerably, and that the *Gleaner*, although of small dimensions, made better weather of it when beam-on to the swell first encountered. The *Gleaner* is said to have "risen over the beam swell and sea like a cork," which is what would be anticipated from the fact that she is a quick-moving ship, her period being only one-third to one-fourth that of the *Resolution.* On the swell which synchronised with the movements of the latter and accumulated rolling, the *Gleaner* could move so quickly as practically to accompany the waves. Everyone knows that under such circumstances the smaller ship is likely to have an advantage; but it is equally true that under most conditions the larger and slower-moving ship will be better behaved than the smaller, and more capable of maintaining her speed.

The *Resolution* was, in fact, put to a severe test at the very commencement of her service, when those on board had not grown familiar with the vessel, and particularly with the fittings provided for use in rough weather. She was not fully prepared when the sea first broke on board, and the washing away of certain fittings which were not well secured, or which were left in place instead of being stowed, permitted water to pass below. This involved discomfort, but not danger; and the statements to the contrary are unfounded. So are the accounts that were published in regard to the straining and leaks produced by the rolling. As to the extent of the rolling, there is no exact information, but there was undoubted exaggeration in the published reports.

(8) PERFORMANCES UNDER STEAM.

In the design it was proposed to develop 9,000 H. P. on the natural-draft contractor's trial of 8 hours, the corresponding speed being about 16 knots; and on the 4 hours' forced-draft trial to develop 13,000 H. P., the corresponding speed being 17.5 knots.

The *Royal Sovereign*, being the first completed ship of the class, was chosen for the purpose of comparing estimates with actual performances. She was brought to her designed load line, and was practically ready for service when the trials were made. On the 8 hours' trial the mean I. H. P. was 9,667, with 0.39 inch air pressure in stokeholds; the revolutions averaged 97 per minute. During the trial 4 runs were made on the measured mile at Stokes Bay. The mean number of revolutions per minute on these runs was 99, the mean power 9,780 H. P., and the

mean speed 16.77 knots. On this basis, the mean speed for the 8 hours was 16.43 knots, including the turns made as the ship ran her trial.

It may be worth mentioning that the speed by log on this trial was 16.32 knots, showing a fair agreement with actual performance. Of course this agreement was accidental, since it is fully recognized that many circumstances seriously affect the indications of the log. But it is the custom of the service to have the log running when ships are under weigh, and to record their indications. Not frequently in published accounts of trials one sees the log speeds given without any notation of the mode of speed measurement; and in some instances I have observed detailed criticisms of relative performances based on log-speed records which were altogether untrustworthy. A far better method of approximating to speeds when making long runs is, undoubtedly, to determine the curves of revolutions for speeds by progressive trials, and to use these results instead of any log yet available.

On the forced-draft trial, the *Royal Sovereign* was run up channel and back in deep water, and over a known distance For three hours' continuous steaming the mean revolutions were 106.3, the mean development was 13,360 H. P., with 1.6 inches air pressure in stokeholds, and the speed (by revolutions) was 18 knots. I may add that this result was checked by a comparison of the "coefficients of propulsion" obtained from the model experiments, at 16.75 and 18 knots.

It will be seen, therefore, that the anticipations of the design were fully realized in regard to the speeds corresponding to the specified powers, and that the actual development was above the specified both for natural and for forced draft.

As all the ships are of identical form, and the screws of the same type and dimensions, nothing was to be gained by repeating the trials for speed, and incurring the expense of ballasting in order to bring them down to their designed load-lines. It was decided, therefore, that the contractors' trials on the remaining ships should be limited to the development of power under the specified conditions, care being taken to immerse the screws sufficiently. The ships were run at draughts and displacements lighter than their completed draughts, varying from 24 feet 1 inch mean draught and 12,100 tons displacement up to 26 feet 11 inches mean draught and 13,500 tons. The *Royal Sovereign* was tried at 27 feet 6 inches draught and about 14,200 tons displacement.

On the natural-draft trial of 8 hours' continuous steaming the developments varied from 9,180 to 9,600 H. P., the air pressures in stokeholds varying from 0.2 inch to 0.5 inch of water. The specification provided for 9,000 H. P., with 0.5 inch air pressure.

In the later ships it was decided not to push the forced-draft trials so far as had been done in the *Royal Sovereign*, but to limit the development to 11,000 H. P. With this limitation it was possible to set the valves so as to favor economy in the use of steam at ordinary working speeds, and to increase the efficiency under general service conditions, when the air pressure in the stokeholds would be not more

than 0.5 inch. With ordinary coal and stoking the specified natural-draft power (9,000 H. P.) would not be exceeded, and not often reached, so that 11,000 H. P. gave a good margin in the engine department.

The steam-producing power of the boilers, of course, remained unchanged.

The mean development on the 4 hours' trials varied from 11,300 to 11,600 H. P. The air pressure varied from 0.35 to 1 inch.

No trustworthy observations of speed were made, but the logs were run as usual. Attempts have been made by some persons to analyze and compare the results, on the assumption that the speeds were correctly measured. All these attempts simply represent so much waste work.

In my paper of 1889 I explained that the greater length of these ships would favor economy of power at the higher speeds, as compared with what had been accomplished in vessels previously built. This has been fully realized on trial, and the following figures are of interest:

The *Trafalgar*, 345 feet in length, and of 12,000 tons displacement at the trial draught (27 feet 6 inches mean), required 8,440 H. P. for 16.22 knots, and 12,900 H. P. for 17.28 knots. The *Howe*, 325 feet in length, 9,600 tons displacement at the mean draught of 26 feet 8 inches, required 8,230 H. P. for 15.9 knots, and 11,600 H. P. for 16.9 knots. The *Royal Sovereign*, 380 feet in length, and about 14,200 tons displacement on the same mean draught as the *Trafalgar*, required 9,780 H. P. for 16.77 knots, and 13,360 H. P. for 18 knots.

Much might be said in further illustration of the point, which was discussed at length five years ago, but these figures must suffice at present.

From personal observations made during the trials of these ships, I can testify that at the higher speeds, even in smooth water, the greater free board of the *Royal Sovereign* class is a source of sensible economy in propulsion. Against the high bow the waves can maintain themselves when once formed, whereas in the vessels of low free board a wall of water is gradually raised above the upper-deck level, until it reaches such a height that it falls over upon the deck, and has to be re-created. In a moderate sea the conditions are still more favorable to the ships with high bows, and the maintenance of speed in rough water is greatly superior.

We are accustomed to adverse criticism of measured-mile performances, which are of great value for many purposes, although no one supposes them to represent what can be done on long-distance steaming. Fortunately it is now possible to refer to a thorough test of the *Royal Sovereign* on a trial made from Plymouth to Gibraltar in October last. The run extended over 72 hours, and was made in fair weather, except for a few hours toward the end, when head winds and some sea were encountered. The mean speed for the 72 hours was 15 knots; the mean power was 8,180, 90 per cent of the specified power. This is an excellent result, most creditable to the engineer officers and their staff. As regards the speed, it is proper to note that the ship started with a considerable load of coal and stores, drawing about 28 feet 6 inches, and

having a displacement of about 14,900 tons. Her consumption of coal for steaming was 484 tons, and for all purposes about 500 tons. Hence her mean displacement for the run was about 14,650 tons. At this speed, therefore, the maximum coal supply (1,450 tons) would suffice to cross the Atlantic at a speed of 15 knots. This is probably an unrivaled performance for a battle ship. The rate of coal consumption was about 1.84 pounds per I. H. P. per hour.

It is interesting to compare this performance on a long run at sea with that of some other battle ships when tried on the measured mile for short periods and with everything at its best, as an indication of what has been accomplished in the direction of economical propulsion.

	Length.	Mean draught.		Displacement.	I. H. P.	Speed in knots.	
	Ft.	*Ft.*	*In.*	*Tons.*			
Royal Sovereign	380	28	2	14,650	8,180	15	Run to Gibraltar.
Alexandra	325	26	1.5	9,430	8,615	15	Measured-mile trials.
Dreadnought	325	26	10	11,000	7.927	14.24	Measured-mile trials.
Hercules	325	24	8	8,676	8,529	14.69	Measured-mile trials.

At cruising speeds also the *Royal Sovereign* has done well. When steaming at a speed of 7.6 knots per hour, the expenditure of 1 ton of coal suffices to drive her enormous weight (over 14,000 tons) more than 7 knots, less than 1,000 H. P. being indicated. For 10 knots speed about 2,500 H. P. is required, and an expenditure of 1 ton of coal would drive the ship about 4.5 knots in fair weather with bottom clean.

Trials have been made as to the most economical mode of propulsion at very low speeds, with the result that it has been found preferable even at speeds of 5.5 to 6.5 knots per hour, to keep both engines at work rather than to work one engine only and use the helm to keep a course. This is a suggestive experiment, taken in connection with the economy anticipated in some quarters by adopting triple screws, in order to work only the central engine at low speeds.

Similar trials made in other twin-screw ships have given confirmatory results.

(9) MANŒUVRING POWERS.

The vessels of the *Royal Sovereign* class have proved very handy for their dimensions, comparing favorably with many ships of less size and weight. They are perfectly under control, answering all movements of the helm even at low speeds. One remarkable proof of their handiness is to be found in the fact that vessels of the class have proceeded under their own steam alone, without the assistance of tugs, from Plymouth Sound into the Hamoaze, a passage involving very awkward turns in limited space and strong tideway. Turning trials have been made with several of the ships, some fully laden and others light. It need hardly be said that differences of draught and trim affect performance.

Taking the seagoing condition, it appears that the tactical diameter

is about five times the length, or about 1,500 feet. This tactical diameter is practically constant for all speeds. The time of turning varies, therefore, nearly inversely as the speed.

At 12 knots the course can be reversed in about 3.4 minutes; at higher speeds in proportionately less time.

The actual space required for turning is practically the same as that required by a number of battle ships from 40 to 50 feet shorter and 2,000 to 3,500 tons less displacement, and taking the ratio of tactical diameter to length, the big ships compare favorably with any battle ship of recent construction and high speed, notwithstanding their great inertia due to the weights and positions of the barbettes and heavy guns.

RELATIVE SIZE AND COST OF *ROYAL SOVEREIGN* CLASS.

In my paper of 1889 I explained that the comparatively large dimensions and displacements of the *Royal Sovereign* class resulted from the fact that they were designed to carry great weights of armor, armament, coals, and equipment at high speeds. As compared with first-class battleships recently built, or now building, for foreign navies, they are of large displacement-tonnage, and somewhat greater draught. As these foreign ships are intended to have about the same speed, while in armor and armament they are designed to meet our ships on fairly equal terms, it has been assumed in some discussions of the subject that our ships are unnecessarily large for their intended service.

To this institution it is unnecessary to explain how fallacious a standard of measurement is displacement-tonnage, apart from a full statement of what is included therein. One requires to know not merely what numbers and weight of guns are carried, what are the thicknesses of armor and areas protected, but also what are the weights of ammunition, coal, stores, and equipment included in the nominal displacement. In other words, what is the total load carried at the maximum estimated speed.

Fortunately, I have been able to make such a comparison between the details of the design of the *Royal Sovereign* class and those of some foreign battle ships of the same date of nearly equal length and of about 12,000 tons displacement. Without going into particulars I can state broadly that the *total load* in our ships reckoned in the displacement and carried at the maximum speeds exceeds that of the foreign designs by about 1,600 tons. This excess is almost entirely made up on the items of coal, ammunition, stores, and equipment.

Everyone familiar with ship designing knows how an addition to the load, with constant speed, leads to a much greater increase than itself to the displacement. But apart from this it will be seen that if the *Royal Sovereign* carried 1,600 tons less than she does—that is, had an equal load with that carried by the foreign ship—she would be about 12,500 tons displacement and would draw about 2 feet 6 inches

less than she does. Of course at this lighter draught she would have a greater speed also.

This is only a typical case. In the Royal Navy the established policy is to give to our ships greater sea-keeping power, more coal, more ammunition, more stores. Hence, with equal skill in design, equal weights of armor, equal numbers and weights of guns, and equal speed, our ships must be of greater displacements.

Thanks to our superior economy in construction, the costs of our ships compare favorably with those of foreign ships. The dockyard-built *Royal Sovereigns* cost about £770,000 ($3,740,000), exclusive of establishment charges and armaments. The corresponding costs for foreign ships of recent construction are from £950,000 to £1,000,000 ($4,617,000 to $4,860,000).

CENTURION AND BARFLEUR.

The *Centurion* and *Barfleur*, also built under the naval-defense act, may be briefly mentioned before concluding. These ships are designed specially for service as flagships on distant stations, and their draught limited, so that they can pass through the Suez Canal. They are wood sheathed and coppered. Their length is 360 feet, displacement about 10,500 tons, maximum speed about 18.5 knots. On trial they have both proved excellent steamers. The net cost (exclusive of armaments) is about £550,000 ($2,673,000).

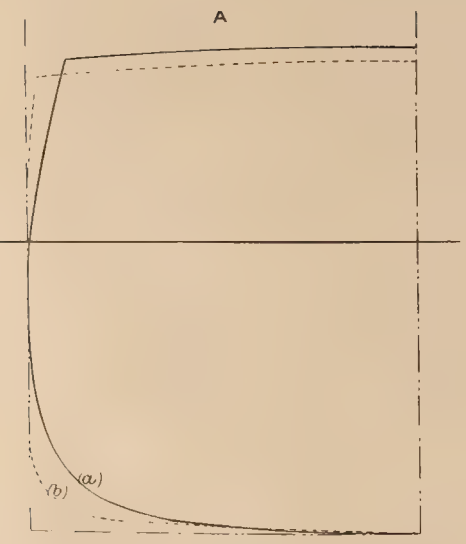
In them we have an illustration of the price paid in reduced offensive and defensive power when first cost is diminished. The *Royal Sovereign* and *Centurion* may be treated as about equal in speed, manœuvring capability, freeboard, coal endurance, and the power of maintaining speed at sea. But to effect a saving of 30 per cent in cost it is necessary to reduce the calibers of the 4 heavy guns from 13.5 to 10 inches and of the secondary armament from 6 to 4.7 inches. The maximum thickness of armor on the belt has to be made 12 inches instead of 18 inches and that on the barbettes 9 inches instead of 17 inches.

As the designer of both classes, I can say that the work on the *Centurion* was as carefully thought out as that on the *Royal Sovereign*. The ships have been built in the same dockyard and under similar conditions. The comparison is, therefore, fair and complete. And the broad result is that, however well adapted the *Centurion* may be for her special service, and capable as she undoubtedly is of meeting on equal terms ships of larger size, but earlier construction, she is distinctly inferior to foreign ships of the first class now building in offense and defense. Her heaviest guns can not perforate the armor on the hulls and heavy-gun emplacements of those ships. Their heavy guns can readily perforate her defense.

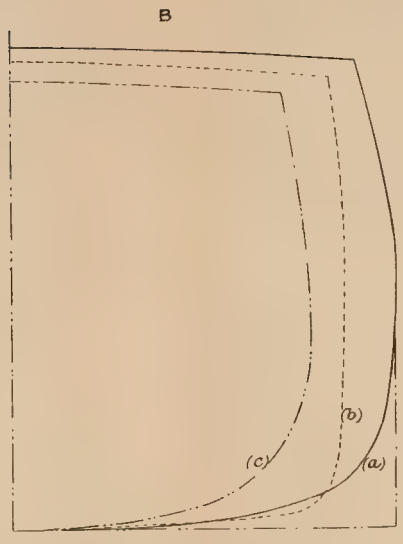
Seven *Centurions* can be built for the cost of five *Royal Sovereigns*. I leave to others the discussion of the question whether such a gain in numbers is any adequate compensation for loss in individual power.

Fig. 1.

Midship Sections



(a.) Midship Section of "Royal Sovereign"
(b) " " Atlantic Liner (Broadened)



(a) Midship Section of "Royal Sovereign"
(b) " " Atlantic Liner
(c) " " "Sultan"

Fig. 2.

Curves of Stability for H.M.S. "Royal Sovereign"

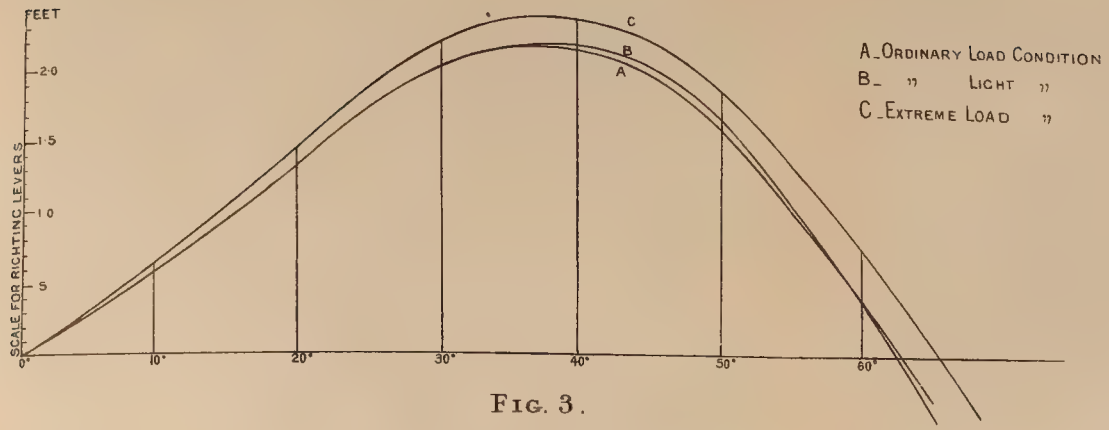


Fig. 3.

Curves of Stability for H.M.S. "Monarch"

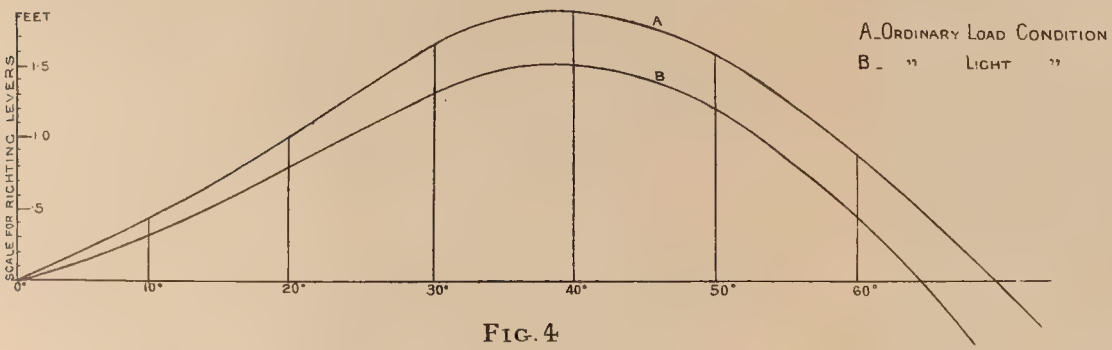


Fig. 4

Curves of Stability for H.M.S. "Devastation"

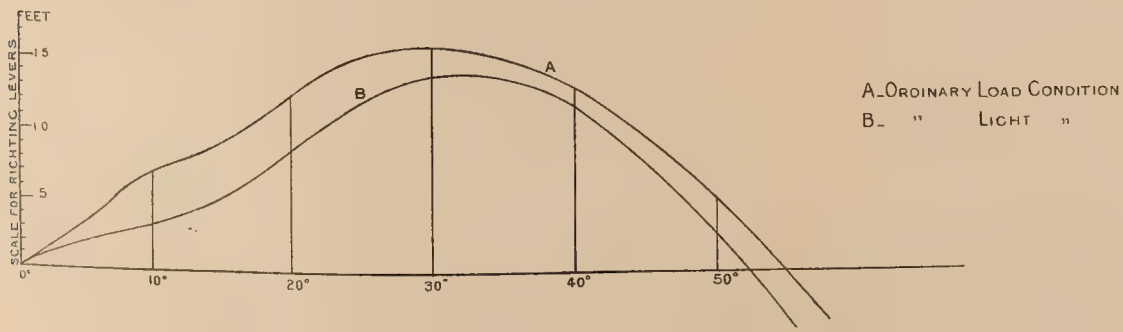


Fig. 5.

Curves of Righting Moments in Ordinary Load Conditions

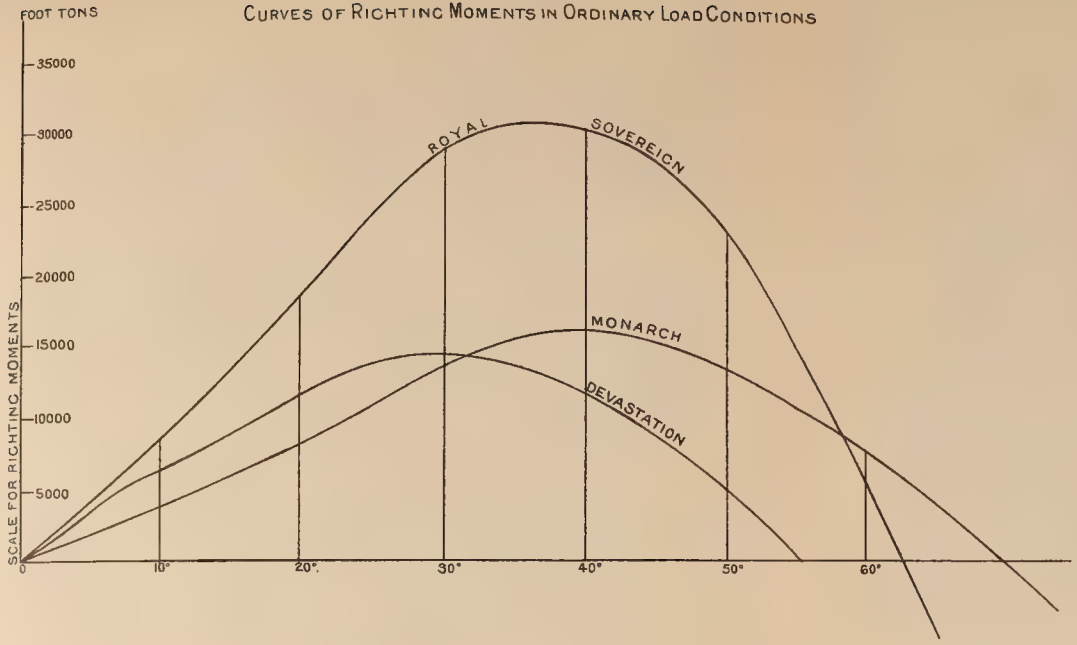


Fig. 6.

Curves of Righting Moments in Ordinary Light Condition.

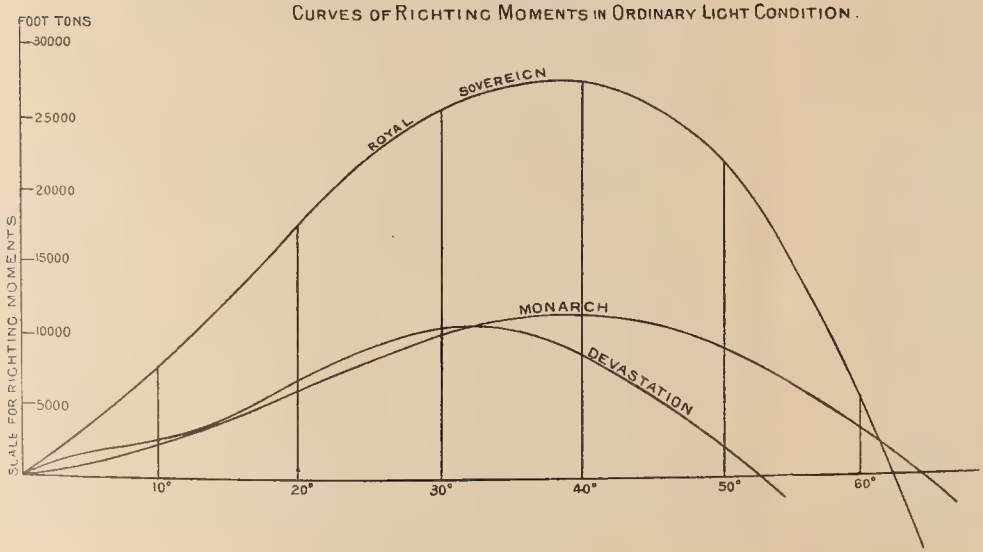


FIG. 7.

H. M. S. "RESOLUTION"

If inclined at 40° in Smooth Water.

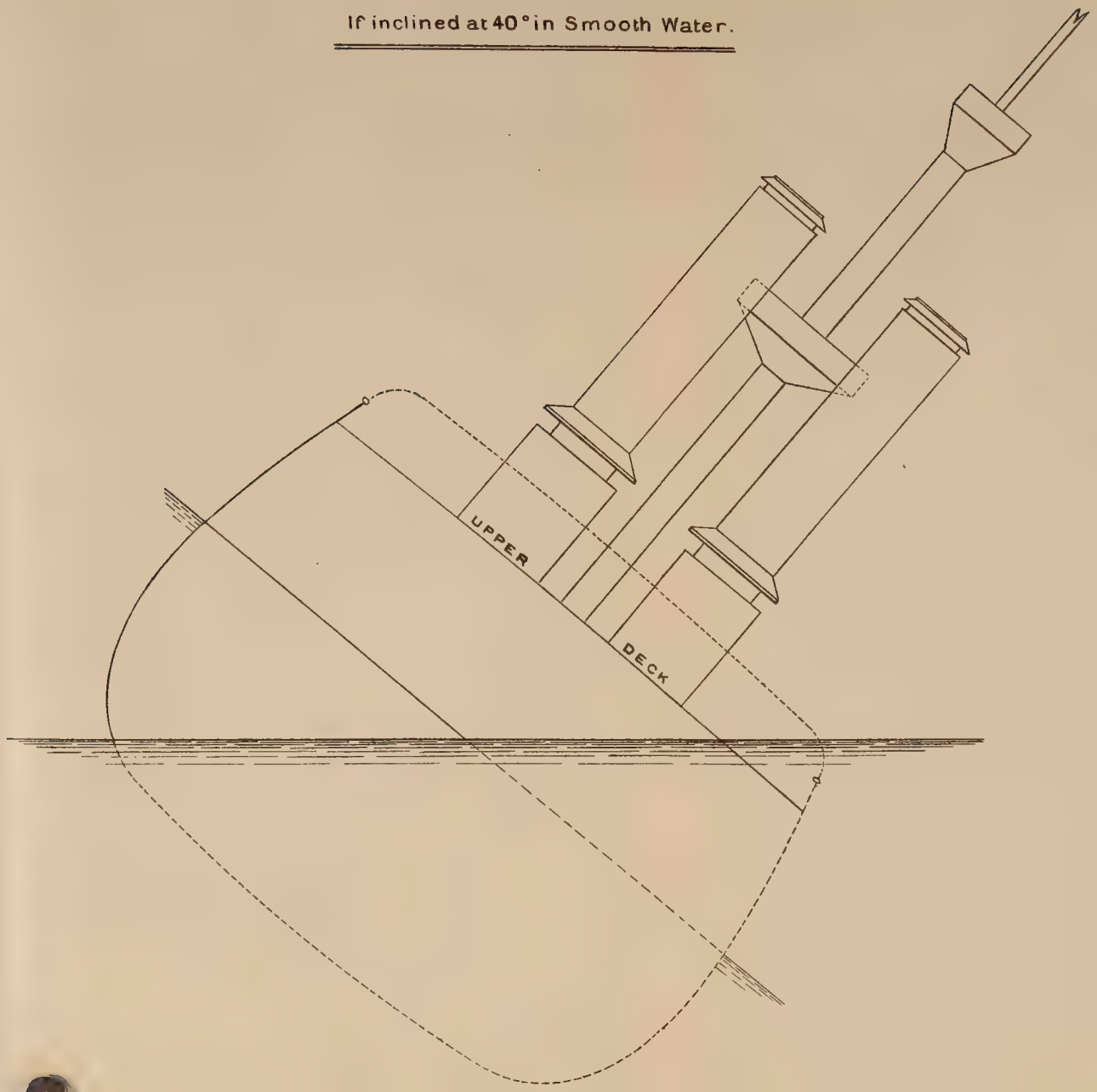


Fig. 8.

H. M. S. "RESOLUTION"

Broadside on to a Wave 600 Ft long, 30 Ft high showing inclination necessary to put her Bulwarks under Water.

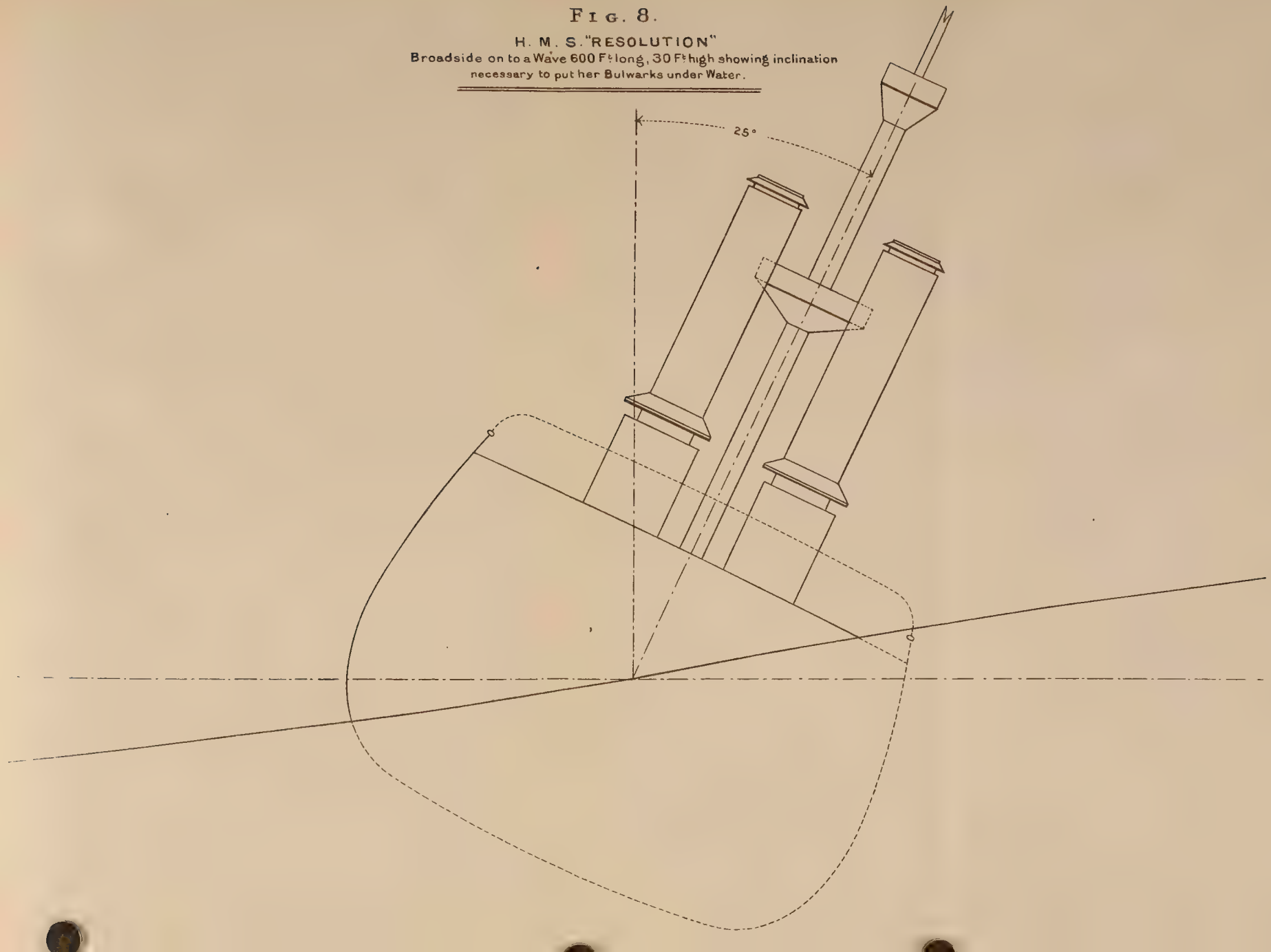


FIG. 9.

H. M. S. "RESOLUTION"

Broadside on to a Wave 300 Ft long, 42 Ft high showing Inclination necessary to put her Bulwarks under Water

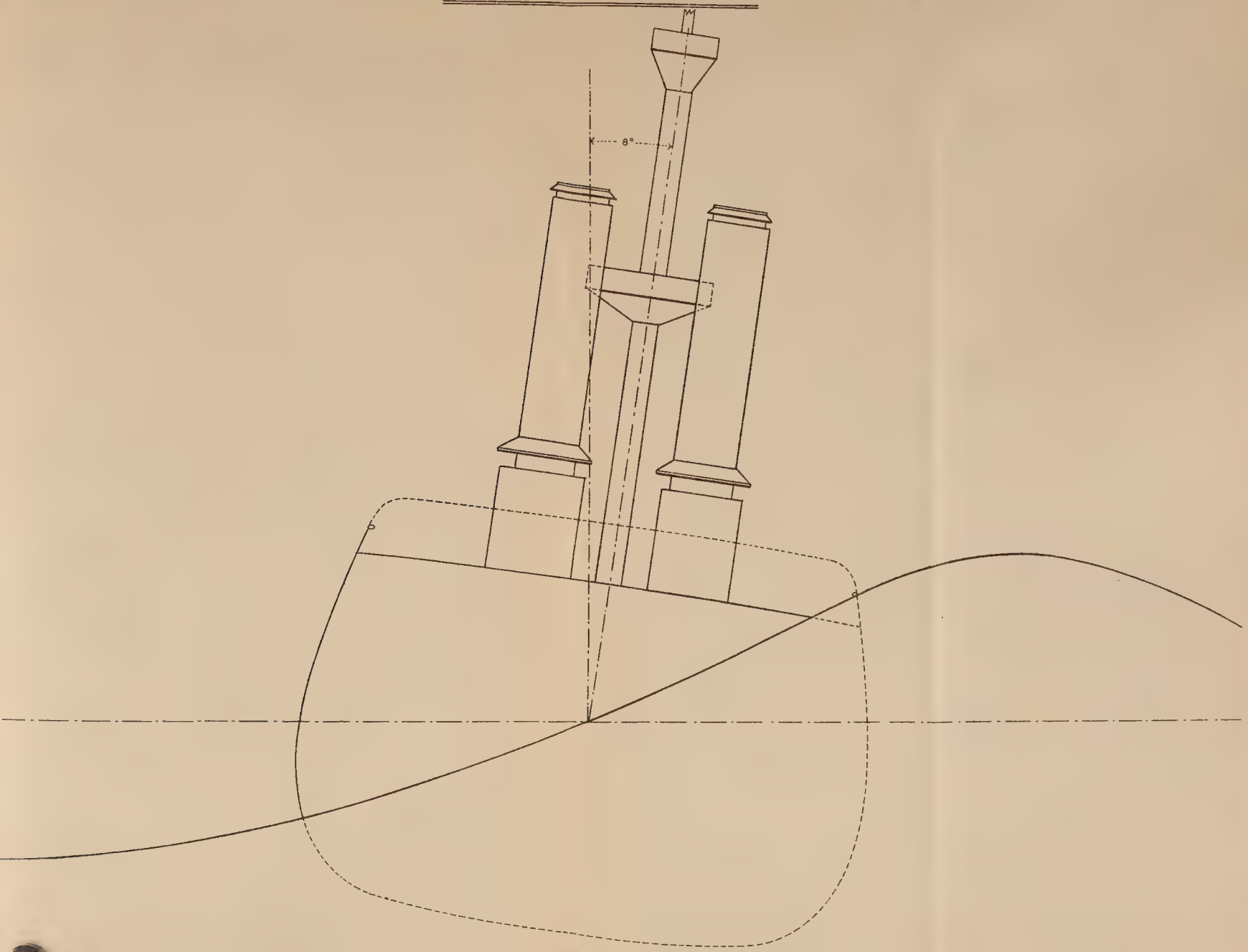


FIG. 10.

H. M. S. "RESOLUTION"

Broadside on a Wave 300 Ft long, 20 Ft high supurposed on another Wave 600 Ft long and 20 Ft high

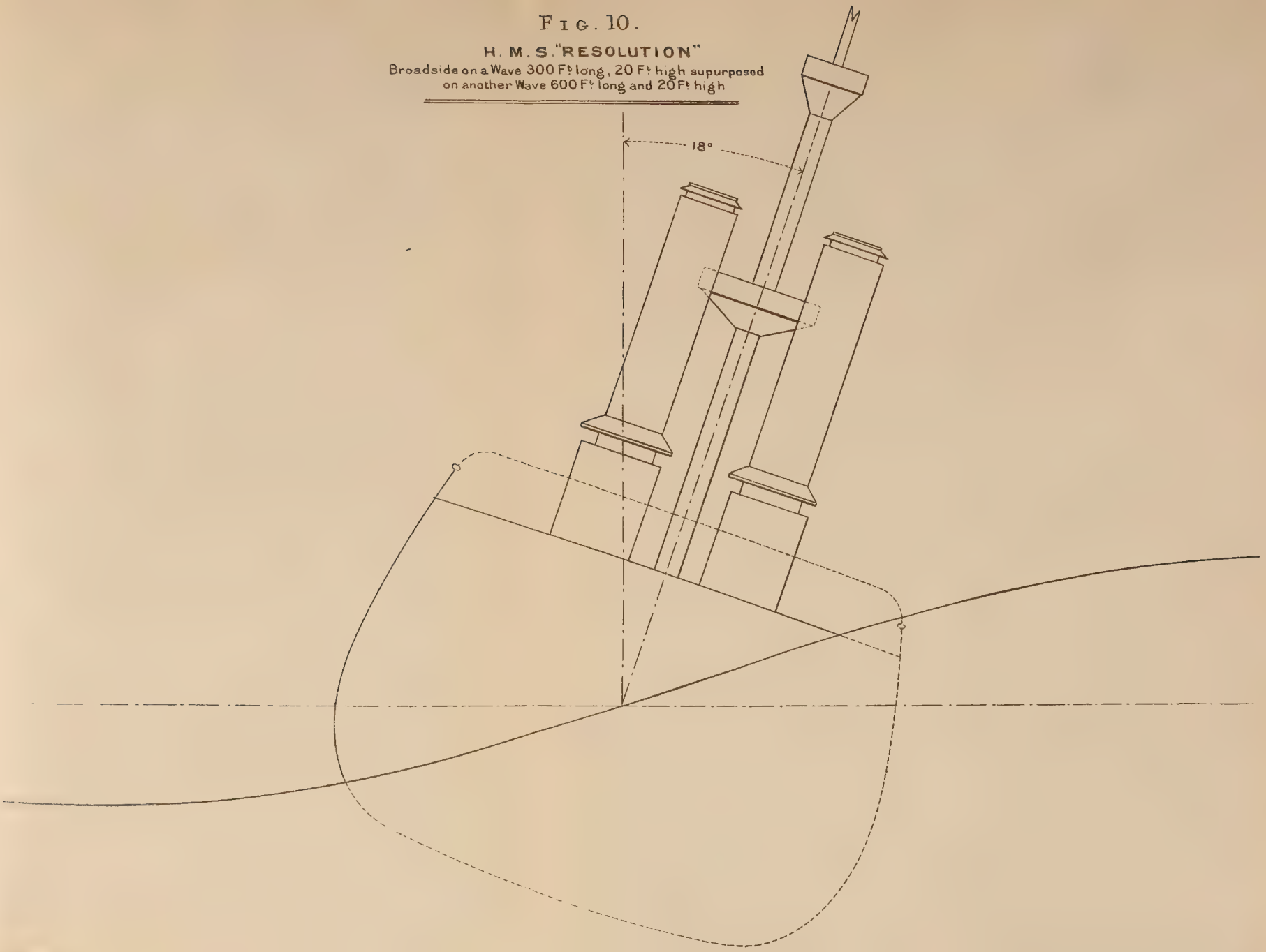
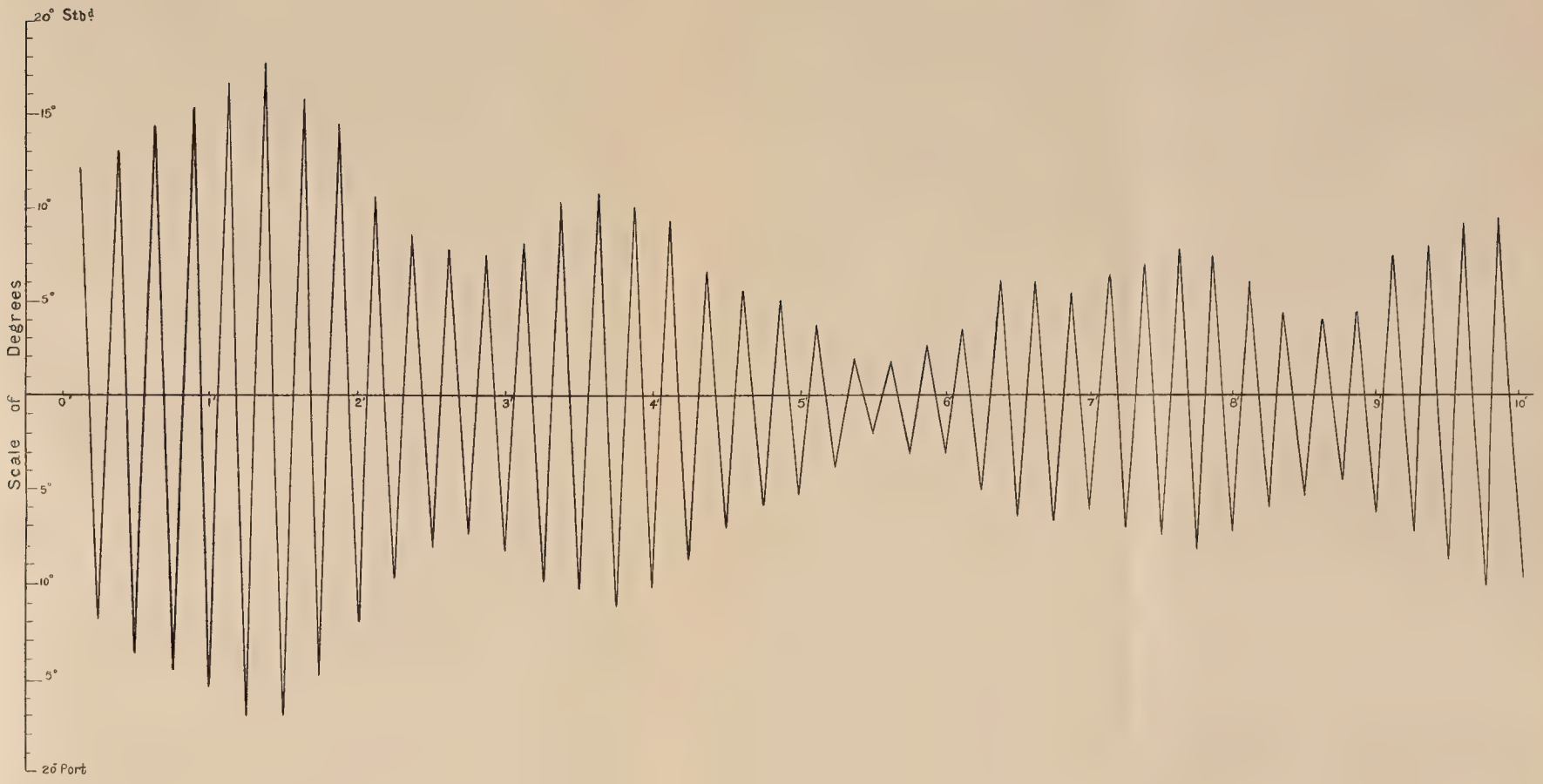


Fig. 11

H. M. S. "ROYAL SOVEREIGN"

Diagram of Rolling for 10 minutes. Swell on the Beam, of period 14 to 14½ seconds.



IX.

SOME NAVAL MANŒUVRES OF 1893.

THE ENGLISH MANŒUVRES.

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THE MOBILIZATION.

Preparations were begun early in June by the issue of orders from the admiralty to have ready for the manœuvres in July the Channel Squadron, the First Reserve ships, and certain specified vessels of the "A" division of the Fleet Reserve. The First Reserve comprises the district ships of the Coast Guard service, and the armored Port Guard ships which have replaced the hulks formerly in use. A distinct improvement in the value of this reserve was made during the year by replacing, in May and June, 5 old-type ironclads of the Coast Guard service by 5 modern high-powered cruisers, and by substituting, after the manœuvres, 4 powerful armor clads for a like number of a weak and obsolete type. They are in commission throughout the year with reduced complements, which are raised to full strength by drafts from the coast guardsmen of their districts when required for active service. The "A" division of the Fleet Reserve is composed of ships not in commission, but in all respects ready for sea, and with a small number of care-takers on board. The vessels of this class designated to be prepared for the manœuvres comprised most of the high-powered cruisers and torpedo gunboats completed during the past two years, many of them not having before been in commission. Efforts appear to have been made to complete the first-class battle ships *Ramillies* and *Empress of India*, and the first-class cruisers *Gibraltar*, *Endymion*, and *Crescent*, in time to take their place in the manœuvre fleet, but unforeseen delays, and possibly a dearth of men for crews, prevented their participation.

On June 23, an order was received at Devonport Dockyard to have crews detailed, under mobilization arrangements for temporary service on the home station, for the following vessels to be commissioned on

July 11: *Æolus*, *Pique*, *Rainbow*, *Retribution*, *Forth*, and *Thames;* to complete the crews of the gunnery practice ships *Conqueror* and *Curlew*, the engineer students' practice ship *Spider*, the Port Guard ships *Swiftsure* and *Rupert*, and the special service vessel *Traveller;* also to commission torpedo boats Nos. *34*, *45*, *52*, *53*, *57*, *58*, *80*, *85*, and *87*.

A similar order was received at the Portsmouth Dockyard to commission on the same date the *Barrosa*, *Iris*, *Intrepid*, *Indefatigable*, *Iphigenia*, *Naiad*, and *Rattlesnake;* to complete the crews of the gunnery practice ships *Hero* and *Seagull*, the Port and Coast Guard ships *Nelson*, *Alexandra*, *Australia*, and *Galatea*, the special service vessel *Magnet*, and torpedo boat No. *82*. In addition, to commission torpedo boats Nos. *59*, *60*, *66*, *77*, *79*, *81*, *83*, and *84*.

At the Nore the order was received to commission on the same date, at Sheerness, the *Jason* and *Jaseur;* at Chatham, the *Benbow*, *Blenheim*, *Barracouta*, *Andromache*, *Apollo*, *Brilliant*, *Sappho*, *Terpsichore*, *Tribune*, *Circe*, *Gleaner*, *Gossamer*, *Grasshopper*, *Salamander*, *Sheldrake*, *Skipjack*, and *Raven*, and torpedo boats Nos. *63*, *64*, *67*, *68*, *72*, and *73*.

At Devonport the cruisers *Pearl* and *Spartan* were ordered ready, but the crews assigned to them having just returned from foreign service and been granted the usual leave, the date of commissioning was deferred; the same was the case with the *Thetis* at Chatham. The *Latona* at Portsmouth was detained, owing to her assigned crew being needed to navigate one of the new battle ships from the contractor's yard to the dockyard. All four of these cruisers were eventually commissioned at their respective ports on July 17.

A fair example of the arrangements made at the several dockyards for commissioning simultaneously the large number of vessels ordered, is contained in the following extract from a general order on the mobilization issued by the commander in chief at Portsmouth:

As soon as possible after the order to mobilize is received the entire crews of all the ships to be mobilized are to be sent to their respective ships as working parties to be employed, under the general superintendence of the captain of the Fleet Reserve, by the officers of the ships who are present. They are to take their dinners with them and return to the depot ships or barracks in the evening on completion of their work. The general depot will arrange for 2 days' provisions being placed on board each ship to be mobilized, except the *Hero* and *Seagull*, for which the parent ships are to be responsible. The ships are to be commissioned at 9 o'clock on the day after the receipt of the order to mobilize, by which hour all officers and men are to be on board. The senior officer of the military branch present at that time belonging to the ship is to hoist the pennant and to report. Having done so all stores, except provisions and ammunition, are to be put on board by the crew on the day of the order to mobilize. Provisions and ammunition are to be alongside the ships at 9 a. m. on the day of commissioning, and the lighters are to be cleared with all dispatch. As soon as this is done the ships are to proceed to Spithead, where they are to make an hour's full-power trial of machinery and are to be swung for the adjustment of their compasses. As regards torpedo boats in the Fleet Reserve, their crews are to join them at once, their coal, provisions, and equipment being sent to the basin in which they are berthed. When completed they are to adjust compasses. The flag

of the commander in chief is not to be saluted by any of the ships commissioned at Portsmouth on their going out of harbor or on their return to Spithead after the manœuvres. Ships and torpedo boats commissioned temporarily for mobilization or summer manœuvres are to be supplied with Whitehead torpedoes in the proportion specified. It having been brought prominently into notice that on several occasions during the manœuvres of 1892 "friendly" vessels did not respond to the "demand" by signal stations, the lords of the admiralty direct that attention be called to the inadvertence, and point out that the movements of friendly vessels would probably be of the greatest importance in the event of war. Signal stations have been directed to endeavor to ascertain the names of the vessels they report when they are satisfied of the friendly nature of such vessels. Signals therefore made from these stations should be promptly attended to. All ships and torpedo boats specially commissioned for the manœuvres are to be supplied with the emergency folios of charts. A, C, and D folios of mounted charts are provided for torpedo boats. Each ship so commissioned is to receive one chronometer. Two large and two small pairs of goggles will be supplied to each torpedo boat engaged in the manœuvres. Commanding officers are to report at the end of the manœuvres as to whether the glasses answer the purpose for which supplied, and which size is recommended for general adoption. The following ships and torpedo boats will be commissioned with crews told off under mobilization arrangement: BARROSA, INDEFATIGABLE, *Intrepid*, *Iphigenia*, *Iris*, *Naiad*, *Rattlesnake*, torpedo boats *59* (divisional), *60*, *66*, *77*, *79* (divisional), *81* (divisional), *83*, and *84*. The crews of the following will be adjusted to seagoing complements: ALEXANDRA, AUSTRALIA, GALATEA, HERO, MAGNET, *Nelson*, SEAGULL, torpedo boat *82* (divisional). The *Latona* will be mobilized at a later date to be notified hereafter.

In addition to the preparatory orders to the commanders in chief at the naval ports, orders were sent from the admiralty to the commanding officers of certain coast-guard districts notifying them that all signal stations on the west and south coasts of Great Britain from the Mull of Cantyre, to Torbay, and on all of the coast of Ireland, and also the naval dispatch centers at Greenock, Liverpool, Pembroke, Devenport, and Portsmouth, would be required for use during the manœuvres.

On July 9, orders were issued for the mobilized officers, including a number of Royal Naval Reserve officers, to join their ships and torpedo boats. The paymasters had been previously ordered to report on board the depot ships at the naval ports by July 8, to attend to the details of provisioning their respective ships and adjusting their accounts.

About 1,350 men arrived at Chatham on July 9, from Devenport and Portsmouth, and 475 from the gunnery school at Sheerness, to man the ships ordered in commission at that port, and on the same date, marines from their barracks, and the many details of sick-bay men from the naval hospitals reported at the several barracks and depot ships, for duty on the mobilized ships.

The interval between the issuance of the preliminary orders and the orders for mobilization, was utilized at the several dockyards by completing with coal and getting all stores, except ammunition and perishable provisions, on board the designated ships. On July 10, all were in readiness for commissioning on the 11th, and the following order was published:

THE 1893 MANŒUVRES.

General Orders and Instructions.

OBJECTS.

(1) The objects of the manœuvres are: On the part of one side to obtain command of the sea between Great Britain and Ireland, and on the part of the other side to prevent this.

SCHEME OF OPERATIONS.

(2) Each of two opposing naval forces—the Red and the Blue—is divided into two separate fleets, stationed a certain distance apart. The Red side is, on the whole, stronger than the Blue, but one of the Blue fleets is stronger than one of the Red, and the two Blue fleets, if united, are together stronger than either of the Red. Each Blue fleet at the beginning of operations is nearer to one of the Red than the latter is to the rest of its own side. A force of torpedo boats is attached to the Blue side. The Red side is to do its best to bring its opponent to action, either with its own forces combined or not, at the discretion of the senior admiral. If the Blue side has either been defeated or has been compelled to retire to a distance to avoid an engagement, and the Blue torpedo boats have been destroyed or reduced to inactivity, the admiral of the Red side is to report by telegraph if he considers that his side has gained command of the sea so that a large expedition may be sent across it.

MANŒUVRE FIELD.

(3) The limits of the manœuvre area will be: On the north, 56° north latitude; on the south, 49° north latitude; on the east, the western coast of Great Britain and the south coast to 3° west longitude; on the west, 13° west longitude.

The space between the parallel of 52° north and 52° 10′ north, extending from the thirteenth meridian west to the Irish coast, is to be considered a "forbidden belt," and is not to be crossed for manœuvre purposes.

(4) The coast of Great Britain south of 56° north latitude and round as far as 3° west longitude will be assumed to be the territory of the Red side.

(5) The coast of Ireland will be assumed to be the territory of the Blue side.

(6) Islands will belong to the territory on the coasts of which they are situated, the Isle of Man being included in the territory of Great Britain.

(7) The remaining coasts of the United Kingdom will be assumed to be neutral. They should not be visited for manœuvre purposes, and if for reasons of navigation or other good cause visits to them are found necessary their neutral character should be paid the respect which would be due to it in real war.

(8) Ships and torpedo boats of one side are not to reconnoiter the ports assigned to the other during the period of the introductory cruises, or before permission is given by the admiralty.

PLACES OF ASSEMBLY, INTRODUCTORY CRUISES, ETC.

(9) The "A" Red fleet will assemble at Portland; the "B" Red fleet will assemble at Milford Haven; the "C" fleet will assemble at Torbay; the "D" Blue fleet will assemble at Berehaven.

(Note.—The forbidden belt may be crossed till permission is given for cruisers to observe movements.)

The Blue torpedo boats, with the ships to be placed at the torpedo-boat stations, will assemble at Falmouth.

The Blue torpedo-boat stations will be as follows: Larne, Belfast, Carlingford, Kingstown, Wicklow, Waterford.

Also in the following ports torpedo boats will be secure against capture: Strangford, Dundalk, Howth, Wexford.

(10) When in all respects ready, the several fleets are to put to sea for a week's exercise, after which "A" is to put into Torbay, "B" is to put into Lamlash, "C" is to put into Berehaven, "D" is to put into Blacksod Bay. All are to complete with coal. The coaling of the cruisers of both fleets should be carried out first, in case their lordships should consider it desirable to permit reconnoitering by cruisers before the actual beginning of "hostilities."

(11) The coast of Ireland squadron, during a period which may be extended to seven days, is to be put through a series of exercises as most desirable under the direction of the senior officer. At the conclusion of the exercises the boats are to be completed for service.

(12) Should reconnoitering previous to "hostilities" be permitted, a telegram to that effect will be sent to officers commanding divisions and squadrons.

The date for the commencement of "hostilities" will be indicated by telegram. Note.—The total time will be ten days.

(13) At the conclusion of the manœuvres target practice, as due, will be carried out.

(14) When the target practice has been completed the divisions, squadrons, etc., will assemble for inspection prior to dispersion at the following places: "A" Red fleet, at Spithead; "B" Red fleet, in Torbay; "C" Blue fleet, at Portland; "D" Blue fleet, in Plymouth Sound.

The inspection being completed, they are to return to their respective ports. The Torpedo-boat Squadron will assemble at Plymouth, and the boats, after being inspected, will return, under suitable escort, to their ports of commissioning.

The organization of the contending fleets was also published on the same day:

The following will compose the Red side, under Vice-Admiral H. Fairfax:

THE "A" FLEET, VICE-ADMIRAL H. FAIRFAX.

First place of assembly, Portland; second place of assembly, Torbay.

Group *a*: *Royal Sovereign, Rodney, Nelson, Conqueror, Narcissus,* and *Blenheim.*

Group *b*: *Sappho, Pique, Naiad, Rainbow, Intrepid,* and *Thetis.*

Group *c*: *Speedwell, Skipjack, Salamander, Jaseur, Gossamer, Gleaner, Spider,* and *Rattlesnake.*

THE "B" FLEET, REAR-ADMIRAL E. H. SEYMOUR.

First place of assembly, Milford Haven; second place of assembly, Lamlash.

Group *a*: *Anson, Thunderer, Rupert,* and *Immortalité.*

Group *b*: *Tribune, Iphigenia, Latona, Mersey, Iris,* and *Bellona.*

Group *c*: *Barracouta, Sheldrake,* and *Grasshopper.*

The Blue side, under the command of Rear-Admiral R. O'B. Fitz Roy, will be as under:

THE "C" FLEET, REAR-ADMIRAL FITZ ROY.

First place of assembly, Torbay; second place of assembly, Berehaven.

Group *a*: ALEXANDRA, SUPERB, BENBOW, AUDACIOUS, AUSTRALIA, and GALATEA.

Group *b*: TERPSICHORE, INDEFATIGABLE, MELAMPUS, ÆOLUS, and SPARTAN.

THE "D" FLEET, REAR-ADMIRAL A. T. DALE.

First place of assembly, Berehaven; second place of assembly, Blacksod Bay.

Group *a*: SWIFTSURE, HERO, and AURORA.

Group *b*: ANDROMACHE, APOLLO, BRILLIANT, RETRIBUTION, FORTH, THAMES, and PEARL.

THE COAST OF IRELAND SQUADRON, REAR-ADMIRAL H. C. ST. JOHN.

First place of assembly, Falmouth; second place of assembly, the several stations.

VULCAN,[1] CURLEW,[1] MAGNET,[1] TRAVELLER,[1] HEARTY,[1] and RAVEN.[1]

Group *c*: BARROSA, JASON, CIRCE, and SEAGULL.

Torpedo boats: Nos. **59, 34, 63, 60, 45, 64, 66, 52, 67, 77, 53, 68, 79, 57, 72, 81, 58, 73, 82, 80, 83, 85, 84, 87.**

The sources from which these vessels were assembled were:

Channel squadron	7
Port guard ships	4
Coast guard ships	8
Commissioned at—	
Devonport	13
Portsmouth	11
Chatham	18
Sheerness	2
Special service vessels in commission	2
Devonport torpedo boats	9
Portsmouth torpedo boats	9
Chatham torpedo boats	6
Total	89

This includes the *Wild Swan*, commissioned later at Devonport for special service on the coast of Ireland.

For convenience in distinguishing between the vessels of the two fleets the names of those in the Red fleet will, throughout this article, be printed in *italics*, and those of the Blue fleet in SMALL CAPITALS and **bold-faced** figures.

The arbitrary values asssigned to the vessels forming the various "groups" were at first kept from the public, but later it became known that each vessel of groups *a* had a value of 12, those in groups *b* of 4, and those of groups *c* of 1. Torpedo boats and special-service vessels not grouped were not assigned a value. These values made "*A*" fleet=104; "*B*" fleet=75; total *Red*=179. "C" fleet=92; "D" fleet=64; COAST OF IRELAND SQUADRON=4. Total Blue=160.

The orders for commissioning were promptly carried out, the pennants being hoisted on all the mobilized ships at the different yards at exactly 9 a. m., July 11. The crews had been marched on board their respective ships at an earlier hour, and immediately the pennants were hoisted the work of taking in ammunition and provisions was commenced.

At Portsmouth the *Rattlesnake* got away from the yard for Spithead at 11 a. m., followed by the *Iris* and BARROSA at 2 p. m., the INDEFATIGABLE at 4 p. m., the HERO at 5:30 p. m., and the others during the evening. The torpedo boats also went out during the afternoon, but owing to bad weather returned to the harbor for the night. The *Rattlesnake*, *Iris*, BARROSA, SEAGULL, and HERO left the same day for their rendezvous. All the others left on the 12th.

At Devonport the SWIFTSURE and *Conquerer* went out into Plymouth Sound within half an hour, and left for their ports of assembly at noon.

[1] Special service vessels not grouped.

The torpedo boats went out during the afternoon, adjusted compasses and tested their machinery and electric plant. The CURLEW and TRAVELLER left at 4 p. m. for their port. The other vessels were taking in ammunition and provisions all day the 11th, and went out into the sound early on the 12th for their engine trials of 1 hour, on the completion of which they left for their respective fleets, with the exception of the *Rainbow*, which had to return to the dockyard for minor repairs. The torpedo boats left on the night of the 12th.

At Chatham, stores only were taken in, the gunboats, except *Gossamer*, leaving the same afternoon for Sheerness, followed by the cruisers, to take in their ammunition and adjust compasses.

At Sheerness 2 vessels only were commissioned, and they took on board stores and ammunition the same day and went out for their engine trials. The *Thunderer* sailed at noon for her fleet. Special arrangements were made for supplying the Chatham ships with their ammunition, and with extra tugs for swinging them for compass adjustment. The Chatham ships arrived during the evening of the 11th, took in their ammunition on the 12th, and 7 sailed for their stations the same day, the others, except the BENBOW, *Jaseur*, *Gossamer*, and torpedo boat No. 68 left for their stations on the 13th.

By the evening of the 14th all the mobilized ships except the BENBOW, still coaling, the *Conqueror*, repairing, the *Gossamer*, repairing, the *Jaseur*, broken down, and the 4 cruisers before mentioned not yet commissioned, had joined their fleets at the several rendezvouses. The Channel Squadron had separated, part to Portland with "*A*" fleet and part to Milford Haven with "*B*" fleet, and all the First Reserve ships except the *Neptune*, of Holyhead, which was not included in the manœuvring fleets, had joined their respective fleets; the *Nelson*, port guard ship from Portsmouth, and the *Conqueror*, gunnery ship from Devonport, to "*A*" fleet; the *Thunderer*, gunnery ship from Sheerness, the *Rupert*, port guard ship from Pembroke, and the *Mersey*, coast guard ship from Harwich, to "*B*" fleet; the ALEXANDRA, coast guard ship from Portland, the AUDACIOUS, coast guard ship from Hull, the AUSTRALIA, coast guard ship from Southampton, the GALATEA, coast guard ship from Queensferry, the SUPERB, coast guard ship from Greenock, and the MELAMPUS, coast guard ship from Kingstown, to "C" fleet; and the SWIFTSURE, port guard ship from Devonport, the AURORA, coast guard ship from Bantry, and the HERO, gunnery ship from Portsmouth, to "D" fleet.

Of the mobilized ships the *Pique*, ÆOLUS, *Rainbow*, and RETRIBUTION, of Devonport, the *Iphigenia* and *Intrepid*, of Portsmouth, the *Blenheim*, the BRILLIANT, *Sapphoe* and CIRCE, of Chatham, and the JASON and *Jaseur*, of Sheerness, had never before been in commission. The VULCAN was commissioned for the first time June 19, 1893, and the *Rupert* on July 5, 1893, for the first time since being refitted with new battery and machinery.

The 5 squadrons being assembled at their first places of rendezvous, as provided in section 9 of the general orders, by the night of July 16, with the exception of the BENBOW, of "C" fleet, were ready for sea on the morning of July 17.

In accordance with the provisions of section 10 of the general orders, the several fleets went to sea on July 17 for the preliminary exercises of one week.

THE PRELIMINARY EXERCISES.

"A" Fleet.—Weighing together at 9:30 a. m., 17th, this, the strongest of the 5 fleets, stood out of Portland, and when clear of the land assumed "cruising order," the battle ships in 2 columns, with the cruisers and torpedo-gun vessels thrown out ahead and on either bow. During the afternoon the latter were detached under the *Narcissus* for steam tactics, while the larger vessels were exercised by themselves at the same time. At dark the light vessels were recalled and the fleet resumed cruising order, steaming slowly down the channel. During the day the crews were exercised at general quarters, fire quarters, and repel torpedo boats; at night at the latter. At 6 a. m., 18th, the cruisers were sent off toward the Scilly Islands to cruise under four-fifths full power and try their speed. They rejoined off the Lizard at 5 p. m., the *Nelson* having proven much inferior to the others. The flagship, steaming slowly up the channel, exercised the gunboats at steam tactics until 3 p. m., when they were all sent off ahead for a trial of speed around Eddystone light-house. Their speeds were found disappointing and for a lengthened run not to be relied upon. The *Speedwell* developed leaky boilers and was sent to Devonport dockyard. During the day the crews were kept at drill, and after the gunboats rejoined, about 6 p. m., cruising order was resumed and the fleet stood slowly up channel. At midnight columns were reversed and headed down channel. July 19, opened thick and rainy, making impossible further steam tactics, and at 3:30 p. m. the fleet anchored at Falmouth, "*B*" fleet coming in shortly after; the "COAST OF IRELAND SQUADRON" was also in port—a total of 61 vessels.

At 11 a. m. on the 20th, "*A*" fleet again went to sea preceded by the COAST OF IRELAND SQUADRON, and followed by "*B*" fleet, both of which were out of sight by noon. The *Thetis*, from Chatham, where she had been commissioned on the 17th, joined during the afternoon; also the *Speedwell*. The fleet steamed at 10 knots in "battle formation" with the battle ships in 2 columns, the cruisers out in all directions covering about 5 miles square, and the gunboats out as scouts beyond the cruisers but within signal distance of them. At dark the cruisers and scouts were called in and cruising order resumed, steaming slowly up channel. During the night the fleet was sent to quarters for repelling torpedo boats. During the 21st, the gunboats were exercised by the *Narcissus* at steam tactics, while the large vessels were put through

more difficult manœuvres by the flagship than had been yet attempted. During these exercises water-tight doors were ordered closed throughout the fleet and kept so until concluded. Crews were kept busy at general quarters and "collision drill." At 4 p. m., the fleet, except the gunboats left at steam tactics outside, anchored in Torbay to send and receive mails, and at 6:30 p. m. went out again, with the exception of 5 cruisers, the *Sappho*, *Pique*. *Naiad*, *Rainbow*, and *Intrepid*, which remained to coal, 6 colliers being in port to supply the fleet. A patent transporter fitted on one of the colliers greatly facilitated the work. The *Gossamer* joined here and was sent out to join the other vessels of her class. During the night the flagship exercised the fleet at steam tactics, standing up and down channel off Torbay. Early on the 22d the *Gossamer* and *Gleaner* were sent in to coal, and the rest of the fleet kept at steam tactics until 2:30 p. m., when they all anchored in Torbay and made preparations for coaling. The *Niger*, replacing the *Jaseur*, was found in port, and the *Conqueror* joined shortly after anchoring, making the "*A*" fleet complete. The cruisers were coaled by the evening of the 23d (Sunday), and the battle ships and gunboats were all filled up by midnight of the 24th. By the evening of the 25th, the fleet was all ready for "hostilities," and signal was made to have steam up and be ready for sea at 10 a. m., 26th, the light craft to have steam up by 6 p. m., 25th, with banked fires, and to be ready to leave on one hour's notice. At 10 a. m., 26th, steam was up in the fleet, and ships hove short. At 11 a. m., permission having been received for cruisers to reconnoiter, the *Pique*, *Naiad*, *Thetis*, *Rainbow*, *Intrepid*, and *Rattlesnake* were ordered off scouting in St. George's Channel under the captain of the *Pique*, senior officer, to watch "C" cruisers and to reenforce "*B*" if it should be met coming south. At 11:30 the gunboats left under the captain of the *Gleaner* to cruise near at hand. The *Blenheim* also went to sea early in the afternoon, taking with her the *Narcissus* and *Sappho* for the purpose of reenforcing "*B*." Learning the following morning that "C" had not finished coaling on the 26th, all the cruisers anchored in Milford Haven during the evening, of the 27th, where the order was received that war would begin a 10 p. m., and at 9:30 p. m. they all steamed off to the S. W. The gunboats, except the *Rattlesnake*, cruised about the vicinity of Start Point. The battle ships were sent out on the 26th, to cruise off and on, the flagship alone remaining port to receive the orders to commence hostilities, which she signaled to the *Rodney*, *Nelson*, and *Conqueror* off the harbor at 6:30 p. m., 27th, and they steamed off, followed at once by the *Royal Sovereign*.

"*B*" *Fleet*—Having assembled at Milford Haven, as ordered, this fleet went to sea on the afternoon of July 17, for the preliminary cruise. Simple steam tactics at low speed were practiced during the day and night, and also during the 18th, while the crews were drilled by day and night at general quarters, fire quarters, and "collision and grounding drill." Particular attention appears to have been paid

to the latter, which consists in closing all water-tight doors, placing a collision mat in a specified position, and lowering certain boats. On account of bad weather on the 19th, tactics were not practicable, and the crews were kept at work at general quarters and "repel torpedo boats" until 6:30 p. m., when the fleet anchored at Falmouth Roads, where the *Latona* joined from Portsmouth, having been commissioned on the 17th, and completing the fleet to its full strength. During the forenoon of July 20, the fleet left Falmouth and proceeded slowly toward Lamlash, on Arran Island, continuing the same drills as before and exercising progressively at steam tactics. On the morning of the 22d, 7 cruisers were sent in to Lamlash with orders to coal, and during the afternoon the rest of the fleet anchored there, when preparations were at once commenced to coal from the colliers already in port. Coaling was completed by the night of the 24th, but watering the gunboats and one or two other vessels was delayed somewhat, owing to lack of facilities. By the evening of the 25th the cruisers had steam up, ready for permission to reconnoiter, as provided in section 10 of the general orders, and at 10 a. m., 26th, the fleet was reported all ready to the admiralty. Sailing orders were issued on the forenoon of the 26th, and at 1 p. m. the *Bellona*, *Iphigenia*, and *Immortalité* sailed, the first passing out around the north side of the island, the others by the south side. The *Latona* and *Iris* cruised between Belfast and Lamlash, looking into Belfast Lough, where the VULCAN, two gunboats, and a torpedo flotilla were seen. About midnight the *Latona* returned to Lamlash for further instructions, and sailed again at daybreak of the 27th. The others under the *Immortalité* cruised to the southward of Mull of Cantyre. Signals from coast guard stations on the evening of 27th gave the news of hostilities to begin at 10 p. m., and the cruisers rejoined the fleet as it was leaving the harbor. The ships left in port kept steam up all day on the 27th, and at 7 p. m. received telegraphic orders to commence hostilities at 10 p. m., and the *Barracouta*, *Sheldrake*, and *Grasshopper* were at once sent out to patrol the entrance and guard against a torpedo surprise. The coast signal stations reported during the day some cruisers of the *Blue* side off the coast. The battle ships went to sea at 10 p. m. and were joined outside by the cruisers.

"C" *Fleet*—The BENBOW, which had been detained at Sheerness coaling since the 12th, joined at Torbay on the morning of the 17th, when, at 10 a. m., the fleet put to sea. Steam tactics were begun, and drills, as in the other fleets, both by day and night. This fleet, being composed entirely of the coast guard ships and mobilized ships, most of the officers and men were new to each other and to their ships, and required more practice. The fleet manœuvred slowly to the westward at about 7 knots during the day and 3½ knots at night, the cruising formation being in 2 columns of 3 battle ships each, with 1 cruiser well out ahead and 1 on either beam. The MELAMPUS was

detached for repairs, on leaving Torbay, and the SPARTAN joined at sea at 8 a. m. on the 19th, having commissioned at Devonport on the 17th. Lizard Light was sighted the night of the 17th, and early on the morning of the 20th, the fleet was off Fastnet Light, on the Irish coast. Shortly afterwards "D" fleet was met, and both fleets manœuvred and exercised at general quarters within easy distance of each other until noon, when "D" went off to the northwest.

Tactics and drills were continued in the same neighborhood until Sunday, July 23, when four cruisers were sent into Berehaven to coal. They went in late at night in a dense fog and anchored, the rest of the fleet going in on the 24th, and anchoring at 2 p. m. Five colliers were in port, from which the cruisers began coaling early on the 24th. One of the colliers was fitted with 2 of the patent "transporters" before mentioned, with a capacity of 90 tons an hour, and delivered coal faster than cruisers could stow it. All the ships were coaled by the 26th, having worked at night, and the fleet was reported ready during the forenoon of that day. The MELAMPUS rejoined at 6 p. m., 25th, completing the fleet. The cruisers had steam up the morning of the 26th, and at 2 p. m., telegraphic orders to reconnoiter having been received, four of them went to sea, the AEOLUS and MELAMPUS to cruise on either side of Isle of Man, the SPARTAN and TERPSICHORE between the Smalls and Scilly Islands, and to then rejoin the admiral on his line of advance, the idea apparently being to meet "*B*" coming south and defeat him before "*A*" appeared. The battle ships unmoored, and having started fires in the morning, were held ready to start on short notice. The same situation was maintained during the 27th, the admiral receiving frequent telegrams from the coast guard stations notifying him of the movement and whereabouts of friendly and hostile cruisers. At 7 p. m. the order was received to commence hostilities at 10 p. m., and at the latter hour the fleet steamed out. The colliers went to Queenstown.

"D" *Fleet.*—The last ship to arrive at Berehaven was the ANDROMACHE, late on the night of July 16, 48 hours from Sheerness; and, as she required coal, the fleet went to sea without her at 9:30 a. m., the 17th, but was rejoined during the evening.

Steam tactics and drills all day and general quarters at night was the first day's programme, and the same on the 18th until evening, when, owing to threatening weather, the fleet returned to Berehaven and anchored. It went to sea again at 9:30 a. m., the 19th, and continued the evolutions and drills, but a thick fog interfering with their continuance the fleet lay all night under steerage way, 20 miles off Bantry Bay, the PEARL, commissioned at Devenport on the 17th, joining at 7 p. m., completing the fleet. The 20th, was devoted to the same exercises, part of the time in company with "C" fleet, and during the afternoon the fleet commenced working slowly at about 4 knots speed up towards Blacksod Bay, where it anchored at 3:30 p. m., the 22d, but

went out again at 5 p. m., leaving four cruisers behind. Colliers were in port, and the cruisers began coaling, finishing early on the 24th. The main fleet returned to port on the evening of the 23d, began coaling early on the 24th, and finished the morning of the 25th, when they were reported ready.

At 6 a. m. on the 26th, all unmoored and got up steam; and, permission having been received, six cruisers at once went to sea to cruise in North Channel and watch "*B*" fleet, the other ships being ready to start on short notice. The PEARL was employed to keep up communication between the battle ships and cruisers. Orders to commence hostilities at 10 p. m. were received at 6:30 p. m., the 27th, and at 10 p. m. the 3 group *a* ships went to sea accompanied by the PEARL.

"COAST OF IRELAND SQUADRON."—The CURLEW, MAGNET, TRAVELLER, HEARTY, and RAVEN, which with the VULCAN were assigned to duty as torpedo depot ships and supplied with spare fittings for boats and torpedoes, assembled at Falmouth, together with the 4 gun vessels and 24 torpedo boats of this squadron. The torpedo boats lay alongside the pier, going out daily for tactical exercise and torpedo practice, and on the 17th filled up with coal and prepared for sea. The entire squadron was also exercised at night quarters. The JASON, having lain so long in the stream at Sheerness, was found to have a very foul bottom, causing a reduction of her speed to not more than 13 knots. Divers of the squadron were employed on her during the 18th, and succeeded in scraping off much of the accumulated growth.

The 20th, being a fine day, the squadron left Falmouth for their stations, the torpedo boats in 3 groups of 8 boats each, convoyed by 3 gunboats. The VULCAN with 4 boats anchored in Belfast Lough off Carrickfergus Castle on the 21st, and laid a telegraph cable from her anchorage to the coast guard station. The CIRCE also anchored the same day near the VULCAN. The CURLEW with 4 boats took station at Larne on the evening of the 22d; the SEAGULL and RAVEN with 5 boats at Carlingsford, the MAGNET at Kingstown, the TRAVELLER at Wicklow, and the HEARTY at Waterford, each with a detachment of torpedo boats to care for. The BARROSA, JASON, CIRCE, and SEAGULL were used at various points along the coast.

The torpedo boats on their passage from Falmouth were exercised at tactics and trying their electric gear. A tendency to burn out grate bars was developed during the passage, and many new ones had to be supplied from the depot ships. After reaching their stations the torpedo boats were occupied at tactics and practicing signals, both by day and night, until the 26th, when all filled up with coal and were reported ready. Owing to mishaps, No. **85** and her substitute, No. **86**, never reached their station on the Irish coast.

Unannounced orders were received at Devonport on July 19, to commission on the 20th, the WILD SWAN, an old vessel with a modern battery, for special service under Rear-Admiral St. John, commanding

the "COAST OF IRELAND SQUADRON." Men who had landed from the transport TYNE on the 15th, were recalled from leave, and the vessel was commissioned, as ordered, with a partial crew and no officers. Her complement of both officers and men was filled up on the 21st, her trials held, and on the afternoon of the 22d, she sailed for the Irish coast, where she was employed inspecting the coast guard and signal stations, all of which had on the 23d, been ordered mobilized, and were fully manned by the 26th. Rear-Admiral St. John had desired to hoist his flag on a suitable vessel and command his squadron afloat, but Admiralty orders required that command should be exercised from his headquarters office in Queenstown, for that purpose directly connected by wire with all the coast signal stations. The WILD SWAN, after filling her mission on inspection service, was ordered back to Devonport on the 4th of August, arriving on the 5th, and was at once put out of commission, the first of the manœuvre fleet.

STRATEGIC MANŒUVRES.

RED.

"*A*" *Fleet.*—The *Royal Sovereign* on leaving Torbay at 6:30 p. m. 27th, was from her superior speed enabled to easily overhaul the 3 battle ships, when they proceeded in company at 12 knots, the highest speed the *Nelson* could maintain, toward Lands End, picking up the gun vessels about 8 p. m. off Start Point, except the *Rattlesnake*, which accompanied the cruisers on the 26th. Formation was taken in two columns of 2 battle ships each, with 2 gun vessels ahead as scouts, 2 off on either beam, and 1 astern, the fleet having a front of 2,400 yards, with officers on lookout, and R. F. G. manned throughout the night as a precaution against torpedo boats. The speed appears to have been kept up, as Lands End was rounded at 3:15 a. m. of the 28th, and the fleet then steering north was off Lundy Isle at 9 a. m., when the *Royal Sovereign* went ahead at full speed, natural draft, accompanied by the *Niger*, to obtain news from the signal station at entrance to Milford Haven. Though developing 9,000 I. H. P., the flagship attained but 14.5 knots, and the *Niger*, doing her best, was not able to keep company and was left behind, the sea being perfectly smooth. The *Rattlesnake* came out of Milford Haven and reported that "C" fleet had not yet appeared in St. Georges Channel, with the exception of some cruisers; that No. 86 had been captured and towed to Pembroke, and that the *Narcissus* had broken down and gone into Pembroke with leaky steam pipes, requiring 4 or 5 days' repairs by the dockyard. At 12:30 p. m. the *Blenheim* and the 6 cruisers signaled the flagship and steamed off again to the northward to meet and reenforce "*B*." Shortly afterward the battle ships and gun vessels came up with the flagship, and the fleet proceeded northwest to get touch with the cruisers. At 1:45 p. m. 4 torpedo boats were sighted and the *Gleaner* was sent in chase; but they all escaped to the Irish coast. The fleet was now in the mid-

dle of St. Georges Channel and sure that "C" had not passed to the northward. At 3:30 p. m. "C" was sighted off on the port hand, steering north, and, about 10 miles distant, 5 battle ships (so rated), 2 cruisers, and 4 torpedo boats, equivalent to a tactical strength of 68, while "*A*," not having its 6 cruisers and 2 battle ships (so classed), the *Blenheim* and *Narcissus*, had but 56 points, not sufficient to escape defeat should the fleets come together. "*A*," however, began edging slowly toward "C," and soon afterward sighted "*B*" coming down from the north in company with the *Blenheim* and her 6 consorts. A thick fog at this time shut down over "C," completely hiding it from view, though its signal guns could be heard. Signal was made about 5 p. m. to "*B*" to form columns of divisions on a course northeast, and then the fog shut down over "*A*" also so thick that the vessels next ahead and astern could not be seen.

"*B*" *Fleet.*—This fleet left Lamlash at 10 p. m. July 27, and was joined outside by its 4 cruisers and the so-rated battle ship *Immortalité*, which had been doing cruiser duty. The fleet then proceeded south at 12 knots, the battle ships in single column with 3 cruisers out ahead, the gun vessels and remaining cruisers thrown out on either beam. The weather was clear, but slightly hazy, with a full moon, occasionally obscured by clouds and smooth sea. The *Rupert*, not being able to keep up the speed set, fell some distance to the rear, and at 12:45 a. m. of the 28th, was approached by a group of torpedo boats coming up astern, but was not struck by a torpedo, as the fleet opened fire and the boats made off. Half an hour later another group, some of them second-class boats from the VULCAN, stationed in Belfast Lough, attacked the fleet from ahead. No. 41 claimed the *Thunderer* and No. 44 the *Tribune* in these attacks, both of which were allowed by the umpires. The fleet claimed all the attacking torpedo boats, asserting that they numbered 22, but was allowed 4 first-class and the 2 second-class boats only. This was the critical point for "*B*," as the passage between the Scotch and Irish coasts is but 24 miles wide here and the torpedo-boat groups at Larne, Belfast Lough, and Carlingford were known to be actively guarding it. After these attacks nothing further was seen of the boats, though the weather became thick about dawn. At 3 p. m. of the 28th, while still steaming south, crossing the mouth of Cardigan Bay, the *Blenheim* and 6 "*A*" cruisers joined from the westward and reported the rest of "*A*" off Milford Haven at noon, and no traces of "C," except his cruisers. These allies were assigned station in the fleet which continued south fully prepared to meet "C," as its strength was now raised to 111 points, quite sufficient to put "C" out of action. Even had the umpires been present with the fleet to make known their decision with regard to *Thunderer* and *Tribune*, there would still be a strength of 96 as opposed to the full "C" strength of 92, making an indecisive action the only result of a meeting. When the rest of "*A*" was sighted, the signals for course, speed, and formation were read; but the shutting down of the fog prevented the latter until a later hour.

Red Fleet.—The junction of "*A*" and "*B*" having been effected, the combined fleet steamed to the northward and eastward for the center of the Irish Channel in no particular formation, all ships sounding numbers on fog whistles and flagships firing half-hour guns until the fog lifted about 8 p. m., when "C" was no longer in sight.

When the fog shut down it was expected that the torpedo boats then in sight would attack under its cover and all preparations were made to receive them, the crews being kept at quarters. The expectation was realized, as within an hour the torpedo boats, guided by the fog whistles and signal guns, got into the fleet, and the reports of rapid-fire guns and small arms could be heard from the flagship in several directions, though nothing was visible of the ships engaged. The *Gleaner*, *Naiad*, and *Pique* claimed to have put out of action Nos. **73**, **58**, and **72**, respectively, but their claims were disallowed by the umpires. Nos. **57**, **58**, and **72** claimed to have sunk the *Pique*, *Sappho*, and *Thetis*, which was allowed. Considerable confusion was caused on the *Red* side by the fog and torpedo attack, and it was not until 10 p. m. that the "*A*" and "*B*" fleets got into formation in 2 columns, the port containing the *Royal Sovereign*, *Nelson*, *Rodney*, *Conqueror*, *Pique*, *Naiad*, and *Rainbow* in the order named; and the starboard, the *Anson*, *Thunderer*, *Rupert*, *Immortalité*, *Mersey*, *Iris*, and *Latonia*. The *Blenheim*, *Intrepid*, *Tribune*, and *Iphigenia* were out ahead as scouts and the gunboats were extended on either beam.

The *Red* admiral recognizing that the *Thetis* and *Sappho* were undoubtedly out of action, ordered them to proceed to Milford Haven for the prescribed interval of 48 hours.

Owing to the absence of the *Narcissus*, still repairing, and *Thetis* and *Sappho*, out of action, the fleet was reduced from its original strength of 179 points to 159 points, and the admiral knew that "C" had passed to the northward and probably effected a junction with "D." Proceeding at moderate speed, showing ordinary running lights, the fleet was a good target for torpedo boats, as the sea was smooth and the moon was occasionally obscured by clouds, and, as the Waterford and Kingstown boats were known to be in the neighborhood, all precautions were taken for repelling them. The *Blenheim* was attacked about midnight, but No. **63** was sighted when within 1,000 yards, and the claim for her destruction by the fleet was allowed. Frequent other attacks were made during the night, keeping a constant state of alarm in the fleet. The *Gossamer* and *Gleaner* claimed a boat, number unknown, which was allowed. The *Thunderer* claimed No. **72**, which was disallowed. *Iphigenia* claimed No. **73**, which also was not allowed. The *Barracouta* claimed Nos. **58**, **72**, and **73**, and the *Tribune* also claimed three boats, both claims being disallowed.

The experience of this night showed plainly that such a strain on the nerves of officers and men could not be sustained for a prolonged period.

About 3 a. m. of the 29th, the light on southwest end of Isle of Man was visible on the starboard bow; a lot of lights under the land were

sighted, which at first were supposed to belong to a fishing fleet. At daybreak shortly afterwards, the lights then bearing E. N. E. were made out to be the BLUE fleet steering south. Vice-Admiral Fairfax decided to attack, although, according to the rules, which are outlined on p. 338, an indecisive action only could result if BLUE were all present; and, signaling to the gunboats and light cruisers to take safe position on the off side, which was not obeyed by all, he increased the speed of the fleet to 11 knots and altered the course of the columns to starboard 8 points to bring the opposing force into action, afterwards hauling up to E. and S., when it was seen that BLUE was not avoiding action.

The engagement which followed, described on p. 322, having lasted an hour, the *Red* admiral signaled "cease firing" and made a signal to his opponent, suggesting that the result be considered indecisive, which was agreed to, and the fleets separated. The last gun was fired at 5:10 a. m., 1 hour and 13 minutes after the first gun; and both fleets were flying the "out of action" signal in less than 32 hours after the opening of hostilities, *Red* having failed in its task of securing command of the Irish Sea.

After the action the rules required both fleets to remain inactive in one of their own harbors for 24 hours after reaching port, and the *Red* fleet stood slowly to southward. The *Grasshopper*, *Gleaner*, and *Sheldrake* were sent into Holyhead for coal as that port was passed, and after a thick wet night the rest of the fleet anchored in Milford Haven at 7 a. m., Sunday, July 30, some of the cruisers commencing coaling at once. All vessels filled up their bunkers during the day, and were again ready for action. The umpires' decision that the engagement was considered indecisive was received and that hostilities could be resumed at 10 a. m., 31st. The decision was also received at this time with regard to the *Red Thunderer*, *Tribune*, and *Pique*, and the BLUE FORTH being "out of action," and their services not available for 48 hours. In the meanwhile the 4 gunboats coaling at Holyhead rejoined on afternoon of 30th, and the *Skipjack*, *Speedwell*, and *Spider* were sent to that port. About 3 p. m., on the 31st, the BLUE cruiser BRILLIANT appeared off Holyhead and attacked the 3 gunboats. After keeping them under her guns for an hour she claimed them "out of action," which was allowed by the umpires. The *Salamander* and *Sheldrake* were lost to *Red* on the 31st, their engines having broken down, necessitating their being sent to Devenport dockyard for repairs.

The *Red* cruisers got under way and left Milford-Haven about 10 a. m., 31st, the *Royal Sovereign* following with the *Rodney*, *Nelson*, and *Conqueror* after noon. Though the *Sappho* and *Thetis* were again available after their 48 hours out of action, *Red* was still short the *Narcissus*, *Salamander*, and *Sheldrake* repairing, and the *Thunderer*, *Tribune*, *Pique*, *Skipjack*, *Speedwell*, and *Spider* out of action, a total of 37 points, reducing her strength to 142. The cruisers were sent off scouting on the coast of Ireland, the *Rattlesnake*, accompanied by *No. 86*, officered and manned from the *Royal Sovereign*, went on a roving cruise to the north, and the

battle ships steamed toward the Irish coast, as it was now the policy of *Red* to avoid an action, and it had been learned from the signal stations that BLUE had left Belfast Lough during the morning, and had been sighted in full force steering apparently for the Welsh coast. It was also learned that the northern torpedo boats had gone south to Kingstown.

On the morning of August 1, *Red* was again off Milford-Haven waiting for the *Thunderer* to come out, her 48 hours' time being up, as also that of the *Tribune* and *Pique*. These vessels joined, bringing *Red* up again in strength to 162 points, and gave the news that at 2:30 a. m., August 1, nine torpedo boats coming from Waterford had made a determined attack on the disabled *Narcissus* and had torpedoed the *Thunderer;* but the latter, being already out of action, could not be claimed. The attack was repelled and *Narcissus* claimed NOS. **72, 67, 64,** which were allowed. Torpedo boats were hovering around the *Red* fleet in the channel during the night; but the night was bright and they did not get a chance to attack, owing to the activity of the cruisers by which the battle ships were covered. During the night of the 31st, the *Iphigenia* claimed NOS. **64** and **67**, and the *Bellona* NOS. **45, 52, 53,** and **79,** off the coast of Wexford, all of which were allowed by the umpires.

Later, during the same night, **64** and **67** were claimed by the *Narcissus* also in Milford-Haven and allowed to her, as before noted. During the forenoon, August 1, the *Blenheim*, *Naiad*, *Latona*, and *Rainbow* went off scouting to the northward, and during the afternoon of the same day chased the FORTH and APOLLO, and kept the latter under fire for half an hour, claiming her on the grounds of great preponderating force, though the time was not up to the 1-hour requirement. The claim was allowed. As the main BLUE fleet came in sight, the chase was abandoned and the *Red* cruisers made off. It was known from the signal stations that BLUE was south of St. David's Head in full force, and, as the aim of *Red* was to avoid an action until the *Narcissus* could join, relying on cruiser actions to reduce BLUE'S strength, the fleet lay to the southward of St. Ann's Head all night of August 1, the *Blenheim* and her consorts rejoining at daybreak of August 2. The *Red* fleet still kept out of the way to the southward all day, the 2d, sending the *Blenheim*, *Naiad*, *Intrepid*, and *Tribune* in to a signal station for news. The gunboats *Speedwell*, *Skipjack*, and *Spider* having finished their time out of action, left Holyhead at 3 p. m. to cruise. At 2 a. m., August 3, the *Blenheim* and consorts rejoined, and reported BLUE gone to Queenstown for coal, the *Narcissus* ready to leave Pembroke by 8 a. m. of the 3d, and the 10 gunboats repairing at Devenport ready to rejoin. The night was blowy and the morning thick, but clearing early in the forenoon, the fleet then lying off St. Ann's Head. The *Bellona* and *Iphigenia* were sent in to hurry up the *Narcissus*, returning at 1:30 p. m. with orders to cease hostilities at 6 p. m., August 4. The *Narcissus* joined at 3 p. m., and the fleet being then up to its full strength, less 5 gunboats absent, stood north into Cardigan Bay in 2 columns, with the gunboats

extended on either beam and the *Blenheim* and 9 other cruisers ahead, covering the line of advance. The night of August 3, was dark, with a choppy sea, though little wind, and all precautions were taken against torpedo boats, running lights only allowed to be shown. At 10:30 p. m. the scouts ahead opened fire, and, search lights being turned on, a flotilla of torpedo boats was seen coming down to attack. One fired her torpedo within about 60 yards of *Royal Sovereign*, but it passed across her bows, just missing the ram, its track plainly visible. The cruisers were claimed by Nos. **52** and **53**, and both allowed. The *Red* fleet claimed these 2 torpedo boats and also Nos. **45** and **79**, the two latter only being allowed. Though only 4 boats appear in this attack it was a success, and the dash and skill displayed under adverse conditions of a rough sea were very creditable to the torpedo-boat officers. The affair was over in a few minutes from opening fire until the boats had passed out of sight in the darkness.

The course was changed during the night to the eastward, and early in the morning of August 4, Holyhead light in sight on port beam, the BLUE fleet was made out coming from the southwest, on a course which would cross the bows of *Red*. The scouts were called in and formed in a squadron astern, under the *Iphigenia* as senior; the gunboats were formed under a cruiser on the port quarter, and the main fleet edged off to meet BLUE in 2 columns.

The fleets were in full sight of each other at 7 a. m., August 4, separated by about 5 miles between nearest ships. BLUE was in line, heading N.N.E., the light cruisers and gunboats being disposed in 2 lines in rear of the line of battle, which contained all the ships of *a* group. *Red* bore N.N.W. from BLUE, and was in 2 columns heading E.S.E., with 4 cruisers scouting ahead and all the other light cruisers and gunboats trailing along in 2 columns astern and on the quarter of the battle ships, the double line being about 3.5 miles long. At 7:35 a. m., the SWIFTSURE being about 1.5 miles from the *Royal Sovereign*, and on her starboard bow, the latter opened fire, at the same time closing the columns to 2 cables and dropping the port column a little astern to form 2 columns indented, thus avoiding masking the fire of the off column, as was done in the engagement of July 29, described under the operations of BLUE. Immediately after fire opened BLUE changed course together 8 points to port, coming on a course W.N.W., in column led by the SWIFTSURE, parallel to *Red*, and heading in the opposite direction. When the fleets had nearly passed in this situation, BLUE again altered course together 16 points to starboard, coming on the same course as *Red*, in single column, led by the ALEXANDRA. The relative positions of the fleets did not materially change until the close of the action, the fleets steaming along parallel to each other, each ship firing 1 heavy gun each 5 minutes until 9:35, when the battle was declared over and the results indecisive. Shortly after *Red* altered course and steamed off to the southward, having again failed in its task of securing control of the Irish Sea.

During the engagement, at about 8 a. m., a detachment of BLUE cruisers attempted to cut off the *Red* gunboats which had dropped too far to the rear of the line of battle; but the movement was observed, and 3 *Red* cruisers were sent back to drive them off, which was done after a short interchange of shots.

The BLUE side was complete during the action, all the vessels which had tactical value being engaged, 25 ships, valued at 160 points, of which 9 classed as battle ships belonged to group *a*, 12 cruisers to group *b*, and 4 gunboats to group *c*.

The *Red* side was short 5 gunboats, the *Speedwell*, *Spider*, *Shipjack*, *Rattlesnake*, and *Sheldrake*, not in company, reducing the force engaged to 28 vessels, with a value of 174 points, of which 10, classed as battle ships, belonged to group *a*, 12 cruisers to group *b*, and 6 gunboats to group *c*. Even had all of *Red* been present the action would still have been indecisive, as 180 points were necessary to defeat the 160 of BLUE and the 5 gunboats would have raised the strength of *Red* to 179 only. The rules so far as published are given on p. 338.

The orders to cease hostilities at 6 p. m., August 4, which were issued on August 3, were unexpected, as the original manœuvre orders provided for 10 days from the commencement, on July 27. Apparently no further strategic lessons could be learned, and the "cease hostilities" order was issued, the *Red* fleet being directed to proceed to Portland, BLUE to Torbay, and COAST OF IRELAND SQUADRON to Falmouth, which also was a change from the original programme as contained in section 14 of the manœuvre orders.

After the engagement of August 4, *Red* steamed south, intending to go into Milford Haven; but heavy weather prevented. During the bad weather of the night the great disadvantage of the low freeboard of some of the ships was seen.

On August 5, the ships dispersed for target practice, the only valuable feature of which was that all ships were ordered to be handled from the conning tower while firing and not from the bridge or other unprotected position. The SPARTAN and *Naiad* used charges of cordite in their 6-inch R. F. G., the first that had been issued for service. The fleet anchored in Portland Roads on the afternoon of August 6; the ships were inspected by their admirals, and the mobilized ships were then dispersed to their stations, to be put out of commission or resume their interrupted duties according to their class in the Reserve.

To test the hospital arrangements, an order was issued from the admiralty on August 6, that each vessel on arrival at its home port was to signal an assumed number of wounded officers and men, of whom a certain proportion should be cot cases. The number assumed by the *Red* fleet was 205, of which 46 were cot cases. Harbor tugs with medical officers and working parties waited on each ship as it arrived in port, transported the assumed wounded over the route, and with the care which would be necessary with actual casualties, and on arrival at the hospital bandages and dressings were examined by the hospital staff.

A report was required from the chief surgeons of the arrangements made, number of cots available, and the efficiency of the bandaging and dressing done by the ships' surgeons in each case. A deficiency of cots was reported at Haslar Hospital; otherwise the arrangements appear to have been good.

BLUE.

"C" *Fleet.*—At precisely 10 p.m., July 27, the seven ships remaining in port left Berehaven, meeting a thick fog as soon as clear of the headlands Course was set for Tuskar Light and the fleet formed in two columns of three (so-rated) battle ships each and preceded by the cruiser INDEFATIGABLE. As the AUDACIOUS could keep up no more than 11 knots, that rate was maintained by the fleet all night, prevailing fog necessitating the constant sounding of numbers on the fog whistles. At daylight on the 28th, the fleet slowed for caution, and the AUDACIOUS was ordered to keep up her speed without regard to the formation, and in case she lost the fleet to rejoin at the rendezvous appointed for the cruisers. She passed ahead and was lost sight of during the day, not rejoining until the following morning. The remaining ships were off Carnsore Point, near Tuskar, by noon of the 28th, and the INDEFATIGABLE was sent in to communicate with the signal station, returning with the news of the passage of "*B*" fleet south of Belfast the previous night and of the torpedo-boat attack made upon it by the Belfast and Larne boats. The fleet increased its speed when the fog was not thick, steering for the rendezvous, and was joined at 2:15 p. m. by the TERPSICHORE, making the tactical strength 68 points. A 3:30 p. m. a fleet was sighted to the southeast, steering apparently north, and 9 ships were counted; but the fog shut down and they were not certainly made out. It was, however, decided to be, as was the case, the main "*A*" fleet, as the TERPSICHORE had reported having been chased by the *Blenheim* and 6 cruisers, and signal guns indicating a flagship could be heard during the two hours the fog lasted. When it lifted over "C," at 5:30 p. m., the other fleet was still enveloped, and "C" went ahead at 14 knots past the rendezvous which had been appointed for the cruisers on the middle of a line between Wicklow and Caernarvonshire, and steered for the second rendezvous, 16 miles northwest of Holyhead, where it was hoped to pick up the AUDACIOUS also. The plan had evidently been to meet the cruisers at the first rendezvous and then with a full strength of 92 points to intercept "*B*" and defeat his 75 points. The absence of the AUDACIOUS made this impossible, and the 3 cruisers being missed in the fogs, made it necessary to proceed to the second rendezvous and get touch with "D." The plan would have miscarried at any rate, as the "*A*" admiral had taken the precaution to detach a reenforcement of 36 points to the assistance of "*B*," and the main "*A*" fleet should have been the adversary sought by "C," had the latter cruisers kept their admiral posted on the new disposition of *Red* forces.

At 7:45 p. m. the first cruiser of "D", the RETRIBUTION, joined and reported that news from a merchant steamer placed a fleet of 12 ships

passing Holyhead at 9 p. m. This could be no other than "*B*" making its way south to join "*A*," and by this time the junction must have been effected, as, in fact, happened a couple of hours previously. The RETRIBUTION was ordered to keep company, and the fleet held its course and speed for the rendezvous. At 10:20 p. m. the SPARTAN rejoined, having been cruising since the 26th, and reported having been chased with her consorts the MELAMPUS and ÆOLUS at 2:30 p. m. by the *Blenheim* and 6 cruisers, but had escaped into Wicklow, where the first news of the existence of hostilities was obtained, and the other two went off to cruise about the rendezvous. At 11:45 p. m. the RETRIBUTION was ordered off at full speed to communicate to "D" the approach of "C," which she did, and remained with her own fleet. At 2 a. m., 29th, "C" sighted a fleet to the northward which was soon recognized to be "D."

"D" *Fleet.*—The 3 vessels of group *a* and 1 cruiser left Blacksod Bay at 10 p.m., July 27, and steamed at 12 knots around the north coast of Ireland. About 11 p. m. the same night the 6 cruisers which had been sent out on the 26th, under general direction of the captain of the THAMES to watch "*B*" at Lamlash were off Larne and not aware of the commencement of hostilities, when they were approached by the torpedo-boat flotilla from that place. The cruisers did not show the private signal and were attacked by the boats. No. **83** torpedoed the FORTH, and, although an ally, the ship was claimed by the commanding officer of the torpedo boat, and the claim was allowed by the umpire. Four of these cruisers rejoined the main fleet on the afternoon of 28th, after it had passed through the north channel, and reported the departure of all of "*B*" from Lamlash for the south at 10 p. m. on the 27th. Later in the afternoon the BRILLIANT rejoined and reported the channel clear, as "*B*" had passed to the south of Mull of Galloway. After midnight the RETRIBUTION rejoined, bringing the fleet up to its full strength, and announced the approach of "C," which was met at 2:30 a. m. on the 29th abreast the Isle of Man, and both fleets proceeded to the southward, with a total strength of 136.

BLUE FLEET.—"C" steering to the westward, having sighted "D," at 2 a. m., abreast the Isle of Man, signaled him to take position, and himself changed course to south. Owing, it is claimed, to the inefficiency of the signalmen, the fleets fell into some confusion, and when at 3:10 a. m. the *Red* fleet was made out coming up in 2 columns from the southward and westward. BLUE was not yet in good order, the battle ship being in two ragged columns, the starboard column led by the SWIFTSURE and the port by the ALEXANDRA, the cruisers being in no particular formation. The AUDACIOUS, MELAMPUS, and ÆOLUS were still absent, and none of the C group of "COAST OF IRELAND SQUADRON" were in company, so the combined strength was short 24 points of its full 160, or 136, a strength which could be defeated by the 159 points of *Red*, then in sight. However, the fleet went to general quarters at

3:30 a. m., and, as *Red* was observed to alter course to interrupt, BLUE also altered course to west, the port column passing through the interval of the starboard one to place the senior officer in the van. The course was then changed together to south, the combined fleet coming into two irregular columns, led by the ALEXANDRA and SWIFTSURE. This formation was quickly changed to a single column heading west by the first division, changing course to starboard in succession, and the admiral signaling to the second division to follow in the wake of the first. A wide gap was made in the column at this point, apparently by mistake of the SWIFTSURE in changing course to port instead of starboard, but, having headed up east and south, *Red* was still in double column. Just at this time the AUDACIOUS joined and took position in column, bringing the fleet up to a strength of 148, making a decisive action impossible under the rules.

Even had the umpires been present with the fleets to give their decision on the spot and notify the admirals immediately a vessel was declared out of action, the action would still have been indecisive, as the *Thunderer*, *Pique*, and *Tribune*, equivalent to 20 points, would have been subtracted from *Red*, leaving it at a strength of 139, while BLUE would have been short the FORTH, and its strength would have been 152.

The general action of July 29.—The *Red* and BLUE fleets went into action with a strength present, as we have seen, of respectively 159 and 148, the *Red* in 2 columns heading east by south, and BLUE in an irregular single column heading to the westward. In this position the battle opened at 3:57 a. m. by a shot from the *Royal Sovereign*, followed almost at once by others from guns of the other vessels. The leaders were then passing in opposite courses, port to port, distant about a mile, fire from main and secondary guns being opened as each vessel came within range of an opponent. B. L. G. of 6-inch caliber and below were fired at 5-minute intervals; heavier caliber were put through the motions only. As the BENBOW passed the *Royal Sovereign* with her two 110-ton guns trained on the same side, she was heeled about 7 degrees, presenting a good deck target. She was followed by the GALATEA and AUSTRALIA in position, then an interval until the SUPERB passed, followed by the AUDACIOUS; then another long interval until the SWIFTSURE, heading her division, came along; then followed a string of cruisers with its rear about 3 miles away. The torpedoes carried by the ships and gunboats were not fitted with collapsible heads and so could not be used. The same reason prevented the use of the second-class torpedo boats, carried by the battle ships, at any time during the manœuvres. When the BLUE fleet had passed, it altered course together 16 points and stood back to the eastward, the *Red* columns about the same time changing course in succession 16 points, the ships turning outward and regaining their distances abreast. The leaders again engaged starboard to starboard as they came opposite to each other. BLUE then again changed course 16 points, coming on the same course with *Red* and parallel to him, distant about three-fourths of a mile. A signal at

this time from the BLUE admiral resulted in his first division swinging together 8 points to port and standing down in line abreast, as if to ram "*A*." The second division did not execute the manœuvre and it has been claimed that the signal was not understood. The two BLUE cruisers MELAMPUS and ÆOLUS rejoined about this time, coming at full speed from the southward and westward, and crossing the bows of the *Red* fleet, it is reported, at about a cable's length distant. The strength of BLUE was thus raised to 156 points. The first division of BLUE was disengaged from its dangerous proximity to *Red* by turning 8 points to starboard, then 8 more points to starboard, finally swinging into column again with its second division heading to the westward, though for awhile it was slowed and lay abreast of the cruisers, bringing up the rear of *Red* columns, and must, if the action had been real, have destroyed them.

The honors of the action appear to have been entirely with the BLUE fleet, judging from the accounts at hand, as its tactics were vigorous and its formation in single column was better adapted to develop its full strength than the double column, by which half the strength of *Red* was marked. The action was now closed by a signal from the *Red* admiral and the fleets separated.

In the absence of the signals made and of an official report of this engagement it is impossible to give an absolutely correct account of what actually happened; but the preceding description is an approximation based on the conflicting accounts of the many correspondents on board various ships of the fleets whose articles have been published in the daily press and service weeklies. A technical account based on official data has not appeared, and would probably be interesting.

Upon separating from *Red* after the engagement BLUE steamed slowly toward the Irish coast, exercising at steam tactics during the afternoon and night of the 29th July, as the "C" and "D" fleets had not had an opportunity of exercising together previously. Early in the morning of Sunday, 30th July, the fleet anchored off Bangor, in Belfast Lough, where the decisions of the umpires were received regarding the vessels "out of action" before the engagement. The BARROSSE, JASON, CIRCE, and SEAGULL, forming group *c* of "COAST OF IRELAND SQUADRON," were telegraphed to join the fleet, which they did during the day, bringing the fleet up to a total of 25 ships and a tactical strength of 160 points; but as the FORTH was ruled "out of action" for being torpedoed by her own side on the night of 28th, the fleet was short her 4 points for 24 hours after the others were free to re-engage. At 4:30 a. m., 31st, the 24 hours in port having expired, the fleet went to sea, and, knowing that *Red* was in Milford Haven steamed south at 5 knots, the heavy ships in an extended line surrounded by the scouts. At 11 a. m. the CIRCE was sent to Kingstown to report the situation to Rear-Admiral St. John and notify him that a number of ships would be in Queenstown in a day or two for coal. The BRILLIANT was sent to look into Holyhead, whence she rejoined at 5.30 p. m. and reported the capture of the 3 gunboats

found in that port. This news was sent to Kingstown by the JASON, and the fleet was formed in 2 columns, course south, at slow speed for the night. Shortly afterwards the CIRCE returned with the news of impending raids by torpedo boats on Holyhead and Milford Haven.

The fleet cruised slowly about off the Welsh coast until about noon of August 1, when the cruisers which had been sent to reconnoiter Milford Haven reported the *Red* fleet off that port. The course was altered and speed increased to intercept him; but the weather was misty and nothing was seen until late in the afternoon, when the FORTH and APOLLO, scouting ahead, were chased by the *Blenheim* and her 3 consorts and kept under fire for 35 minutes, until the main fleet was sighted close to, and the 4 *Reds* drew off. If they had been chased by a stronger force it is probable that a capture would have been made, as the *Rainbow's* engines gave out soon after, the brasses having run. The fleet then headed for the Irish coast, and several cruisers went into Queenstown to fill up with coal. Early a. m. of August 2, the MELAMPUS, ÆOLUS, SPARTAN, BARROSA, CIRCE, JASON, SEAGULL, and AUDACIOUS anchored in port and coaled, going out again the following morning to rejoin the fleet, cruising slowly off and in the harbor, the rendezvous being 15 miles east of Old Head of Kinsole. By 11 a. m., August 3, the fleet was together, except the ÆOLUS and JASON, still in port, and, without waiting for them, steamed for Tuskar Point. At 1:30 p. m., the SEAGULL was sent in for news from Corsons Point signal station, and at 2 p. m., the THAMES, INDEFATIGABLE, and PEARL under the AUSTRALIA, were sent out to reconnoiter Milford Haven, but with orders to avoid any possibility of capture. The ÆOLUS and JASON joined shortly after, and the fleet proceeded to the northward and eastward, being obliged to wait a couple of hours for the AURORA, with 1 engine disabled, and whose 12 points could not at this time be risked away from the fleet. At 9 p. m., the SEAGULL rejoined, with the news that hostilities cease at 6 p. m., August 4, and by 10 p. m. the fleet was steaming at increased speed, with the scouts thrown well out up the Irish Sea. By 11 p. m., the AUSTRALIA and her consorts returned and reported Milford Haven clear of *Red*, as it was known that that fleet must be to the northward. BLUE was now at its full strength, 25 ships, counting 160 points, and safe from the possibility of defeat by the full strength of *Red*. About 4 a. m., August 4, the GALATEA, signaled "one engine disabled," indicating the serious loss of 12 points; but after awhile she managed to keep in position and in time to take part in the action which followed soon afterwards, the scouts signaling the *Red* fleet at 6:10 a. m. and falling back on the main fleet, when the indecisive action, already described, was fought, and the fleets again separated for their own ports, "out of action" until the close of hostilities. The BARROSA was sent to Kingstown with the news of the engagement, while the main fleet steamed slowly to the northward. The *Red* fleet was nearly out of sight, and BLUE was off Holyhead, when far ahead the *Red* gunboat *Rattlesnake*, accompanied by the captured *No. 86*, was seen approaching. They were fired upon by

one of the ships, but the others, not considering it practicable warfare for two such craft to attack at noontime of a clear day a fleet in battle formation, did not open fire. The *Rattlesnake* drew off when she got close to the leading ships, and the torpedo boat made her attack alone, discharging her torpedo at the ALEXANDRA when half a cable distant and striking her on the beam. The attack was of course ignored.

The fleet then proceeded to Belfast Lough, anchoring off Carrickfergus at 6 a. m., August 5, when such vessels as needed it at once began coaling. The fleet lay in port over Sunday, 6th, and at 8: 30 a. m., the 7th, "C" left and steamed south to Jones Bank, 40 miles west of Scilly Islands, where it arrived on the night of the 8th, and early a. m., on the 9th, dispersed for great gun target practice, which was carried out very fully for the benefit of the coast guardsmen, who to a large extent manned this fleet. On the 10th the ships reassembled at a rendezvous near the Scilly Islands, and the fleet proceeded to Torbay, where it anchored at 8 a. m., 11th. After inspection by the admiral the ships dispersed to their ports, the same orders with regard to wounded being observed as in the case of *Red* fleets.

"D" fleet left Carrickfergus at 10:30 a. m., August 7, and steamed south. On the 8th, it dispersed for great-gun target practice, reassembling at Penzance the night of 9th, and anchoring in Torbay on the 10th, for inspection and final dispersion to home ports. The instructions for assumed wounded were also observed.

Orders were issued on the 8th, detaching all naval reserve officers, officers on leave or preparing for sea, and acting sub-lieutenants as soon as they could be spared without waiting for their ships to pay off; also, granting 7 days' leave to all men engaged in the manœuvres. All of BLUE had dispersed to their ports by the evening of the 12th.

"COAST OF IRELAND SQUADRON."—The torpedo-boat flotilla went to sea at 10 p. m., 27th, the Larne flotilla attacking her allies, the cruisers of "D" fleet, shortly after getting outside. The two leading boats fired their torpedoes and claimed the FORTH, as before described. The Belfast boats, accompanied by the Larne boats and the VULCAN'S second-class boats, shortly after midnight attacked "*B*" fleet, and claimed the *Thunderer* and a second-class cruiser (*Tribune*), which were allowed by the umpires. All the attacking boats were claimed by "*B*" fleet, but only 4 first-class and 2 second-class were allowed. The Waterford and Kingstown boats made several attacks on vessels of the "*A*" fleet, and during the fog of the evening and night of 28th, were successful in putting out of action the *Pique*, *Sappho*, and *Thetis*, though the two latter only were at once ordered into port by the "*A*" admiral. Early a. m. of 29th, the Waterford flotilla, comprising Nos. **45, 52, 53, 59, 60, 66, 77,** and **79**, arrived in Kingstown from this cruise.

The results of the torpedo-boat attacks from 10 p. m., 27th, to 4 a. m., 29th, were: Loss to *Red* fleet, the *Thunderer*, *Tribune*, *Sappho*, *Thetis*, and *Pique*; loss to BLUE fleet, the FORTH, NOS. **86, 83,** 5 first-class and 3 second-class boats.

The season was somewhat adverse to the torpedo boats, as the nights from July 27, to August 7, had very little darkness, and until August 1, practically none, owing to the fullness of the moon. The prevalence of fog, however, gave them opportunities which without it would have been lacking.

The northern torpedo boats were all ordered south by telegraph on the 30th, 10 of them with 2 depot ships (Nos. **34, 59, 60, 73, 80, 81, 82, 83, 84, 87,** TRAVELLER, and MAGNET) putting into Kingstown during afternoon of the 31st.

At 6 p. m., 31st, a flotilla left Kingstown for a raid on the enemy's coast. Four boats went to Holyhead and, entering the harbor at 11 p. m., got near the 3 gunboats lying there, but the latter had been put out of action the same day by the BRILLIANT and were not attacked. They all returned to Kingstown early a. m. of August 1. During the same night 3 of these boats fell in with the BLUE fleet, and were ordered south to attack a *Red* cruiser supposed to be in the vicinity. They sighted a vessel shortly afterwards and attacked her from ahead, a boat passing on either side of her and striking her with their torpedoes. The private signal was then shown by the vessel, which proved to be the MELAMPUS, a friendly cruiser scouting about 15 miles ahead of the fleet. Nos. **83** and **87** claimed her, and it was allowed, reducing Blue to 156 points for 48 hours. No. **83** was the same boat which torpedoed the friendly FORTH on the 28th.

Nine boats went out from Waterford on the evening of the 31st, and at 11 p. m., August 1, entered Milford Haven for an attack on *Red* fleet, part of which they supposed to be anchored there. The boats cautiously followed the shore up the harbor, and at 2:30 a. m., August 1, made an attack on the only vessels they found, the *Narcissus*, under repairs, and *Thunderer*, "out of action." The latter was supposed to be the *Conqueror*, and, although showing a light to indicate that she was not in action, it was not seen, and No. **67** struck her on the beam with her torpedo. The torpedo was lost, and the boat's steering gear going wrong, she was obliged to anchor. No. **72**, guided by the searchlight of the *Narcissus*, went higher up the bay, lashed alongside a fishing smack and was followed by several others, but they were sighted by the picket boats of the *Narcissus* and opened on with the boat guns before they got within torpedo range. The warning enabled the *Narcissus* to open with her guns and fire the necessary number of rounds, when No. **72** went alongside and acknowledged itself "out of action," and then left for her station at Waterford. Finding No. **67** disabled and at anchor No. **72** towed her to Pembroke dockyard, where a crew from the *Narcissus* took charge. No. **72** then left the harbor, encountering the *Red* cruiser *Tribune* about 10 a. m. at the entrance coming in with orders from the admiral to hold the captured boats. The boat showed the "out of action" signal, but kept her course, and was fired upon by *Tribune*, and afterwards by other cruisers and gunboats; but she escaped from them all among the islands to the northward of the harbor. No. **64**, another

of the boats in the attack on the *Narcissus*, in leaving the harbor got aground and 2 picket boats from the *Narcissus* attacked her, firing into her at close range with their boat guns. The torpedo boat not having her guns mounted could make no reply and was fairly captured; but by working her engines she got clear of the ground, and, slipping among a lot of colliers, anchored near by, managed to get away to sea. The *Narcissus* claimed all three of these boats and the claim was allowed.

During the evening of August 2, No. **58** was found alongside a lighter in Milford Haven by a picket boat of the *Narcissus*, which opened fire with a 7-pounder at 10 yards distance and captured the torpedo boat. She was taken to Pembroke, and her high-pressure slide valve cover removed to prevent her escaping; but a couple of the crew took the shield of a machine gun on shore, and with the aid of a local shop made a substitute, with which they were enabled to work their engines and escape from the harbor. Some hours after the capture of No. **58** the *Narcissus*, hearing a torpedo loosed close aboard, discovered that it came from a collier's punt, which was captured and brought alongside, and found to be manned by the gunners of Nos. **72** and **58** and the captain of a collier, to whom the punt belonged, all disguised as colliers' men, and all of whom were put under arrest for violating the rules, as both boats were "out of action" and No. **72** had been ordered to her station at Waterford on the 1st. A torpedo had been slung alongside the punt, and when within very close range of the *Narcissus* it was released, but missed the ship and stove a hole in a steam launch. At 5 p. m., August 3, Nos. **79**, **53**, **52**, and **45** left Wicklow and made the attack on *Red* fleet, before described, losing Nos. **45** and **79**, and destroying 2 second-class cruisers. They returned to their port early a. m., August 4, after a very rough night.

All torpedo boats were ordered to their stations on August 4, the three Larne boats encountering the *Rattlesnake* on the passage from Kingstown. No. **34** was captured; but the other two outran her and escaped. The *Spider*, *Speedwell*, and *Skipjack* also chased a flotilla on the 4th, claiming and being allowed 1 first-class boat.

Immediately on the cessation of hostilities the squadrons began leaving their respective stations, the last of them arriving at Falmouth by August 7, when after target practice by the gunboats and inspection of all the vessels they were dispersed to their home ports, all observing the orders about wounded.

COMMENTS.

Naval strategical manœuvres are of value, as they enable officials intrusted with the formulation of a policy for national defense to inform themselves of the probable action of experienced fleet commanders in particular circumstances of war, whence proper legislative action for attaining the desired security may be intelligently inaugurated. The fleet commanders have the practice and gain the experience of working out in peace the problems which would probably be given them to solve

in war, and with the same fighting units and a similar responsibility for a proper solution as would fall to their lot should peace be interrupted.

Naval tactical manœuvres serve a different, but no less valuable, purpose. The units of a fleet require exercise together for the same reason that such training is required by the units of a regiment before it can be classed as superior to a mob. The individual worth of the men of a regiment or the ships of a fleet may be great but if they lack the training which would enable them to act in concert their value is lost should the warfare extend beyond guerilla work in the one case or single-cruiser raids or scouting in the other. Mobility of a fleet in war is as much a necessity as is that of a regiment in the field, and an assemblage of ships whose officers have been insufficiently trained in tactical evolutions would in action be quite as dangerous to each other and as little worthy of consideration by a trained enemy as would a regiment of riflemen whose drill had never extended beyond the manual of arms.

A proper appreciation of this has led business-like powers to concentrate their naval strength in fleets which are constantly drilled at steam tactics, that their officers may acquire the art of handling ships with alacrity, precision, and safety when at high speed in the close proximity to each other which must always prevail in a fleet manœuvring or cruising in company.

When large numbers of reserve ships are added to the regular fleets, as is done each year in most countries for more or less extended peace operations, a part of the time is always devoted to the tactical instruction of the personnel, valuable alike to the captains, lieutenants, and quartermasters, and also to the engineer force.

The British manœuvres this year included three distinctly instructive sets of operations:

First. The mobilization or bringing together 89 vessels of all classes, with full crews and ready for any service, to supplement the 7 ships of the channel squadron, already in active service on the coast.

Second. A week of "preliminary exercises" to drill the officers at tactical manœuvres, the crews at their stations, and make fleets of the assemblages of ships.

Third. Ten days of strategical manœuvres to demonstrate certain problems which might require solution in case of foreign war. This period was afterwards shortened to eight days.

From the accounts published, the mobilization arrangements appear to have been satisfactory. A delay occurred in the case of the BENBOW, attached to the reserve of Chatham, a port from which she could not get out with all her weights on board, making it necessary to complete her coal at a neighboring port after commissioning, which prevented her joining her fleet for several days after the other ships had reported at their rendezvous. But as a whole, the mobilization of

this large fleet of modern vessels, the most powerful that has yet been brought together, was a very creditable performance. The mishaps were few, and with one exception of minor importance, the orders were punctually carried out, the officers and men detailed for the various classes of vessels took up their duties without confusion, and efficiently handled the new machinery and armaments, facts which speak well for the organization and training of the personnel. That the latter is not strong enough for the thorough efficiency of the navy is, however, plainly apparent, and some embarrassment was caused by the difficulty in concentrating enough officers and men to man the fleets.

It became necessary to cancel part of the leave granted to two ships' companies just returned from foreign service, to defer the commissioning of a cruiser needed for foreign service, and to postpone the steam trials of a new battle ship. This scarcity of men was the apparent reason for some modifications in the list of ships as first published to take part in the manœuvres, and some of the newest and best types were not represented. In case of a call for the complete mobilization of the fleet it is difficult to see where trained crews would come from, as in this partial mobilization, when a long list of available ships were not called out, the naval depots were denuded of men, with the exception of the few required for harbor-service vessels. When, on July 19, it was decided to commission for special service during the manœuvres the small old-type cruiser *Wild Swan*, it was necessary to recall from leave men who had landed but four days previously from the China station. Even at Devenport and Portsmouth, where there was a surplus of the seamen class, utilized to man the Chatham ships, considerable difficulty was experienced in supplying sufficient men of the engine and fire room force. On the other hand, the Royal Naval Reserve men were not called out and all the coast guardsmen were not utilized, the half which went to sea in 1892 not being disturbed.

The lack of lieutenants also was felt, the mobilized vessels being under-officered in that grade, and 9 of the torpedo vessels, which are lieutenants' commands, were given to commanders. The detail of Royal Naval Reserve officers to service in the manœuvring fleet was larger than usual, numbering 25 lieutenants, 8 sub-lieutenants, and 2 midshipmen. Two retired commanders and 1 retired lieutenant were attached to flagships as coaling officers of fleets, the fourth fleet having a lieutenant on the active list for the same duties, which in time of war would be of the greatest importance. The total number of vessels engaged in the manœuvres was 89, including 24 torpedo boats; the guns carried of 4-inch caliber and over, numbered 498, and of less caliber 846, in addition to which 364 tubes for discharging Whitehead torpedoes were carried. The officers numbered 1,179, and the petty officers and men 18,845, distributed to the various ships as shown in the subjoined tables.

Name of ship.	Class.	Displacement.	Maximum speed.	I. H. P.		Battery.			Admirals and staff.			
				Natural draft.	Forced draft.	Guns, main.	Guns, secondary.	Torpedo tubes.	Vice-admiral.	Rear-admirals.	Flag lieutenants.	Secretaries and clerks.
"A" FLEET.		*Tons.*	*Knots*									
Royal Sovereign	Battleship	14,150	17.5	9,000	13,000	14	33	7	1	..	1	3
Rodney	do	10,300	16.7	7,500	11,500	10	21	6	..	..	..	....
Nelson	Armored cruiser	7,630	14.4	5,500	6,600	16	16	4	..	..	..	....
Conqueror	Battleship	6,200	15.5	4,500	6,000	6	15	6	..	..	..	....
Narcissus	Armored cruiser	5,600	18.5	5,500	8,500	12	20	6	..	..	..	....
Blenheim	do	9,000	20	13,000	20,000	12	24	4	..	..	..	....
Sappho	Protected cruiser	3,400	20	7,000	9,000	8	13	4	..	..	..	....
Pique	do	3,600	19.7	7,000	9,000	8	13	4	..	..	..	....
Naiad	do	3,400	20	7,000	9,000	8	13	4	..	..	..	....
Rainbow	do	3,600	19.7	7,000	9,000	8	13	4	..	..	..	....
Intrepid	do	3,600	19.7	7,000	9,000	8	13	4	..	..	..	....
Thetis	do	3,400	20	7,000	9,000	8	13	4	..	..	..	....
Speedwell	Torpedo vessel	735	19.5	2,500	3,500	2	4	5	..	..	..	....
Skipjack	do	735	19.5	2,500	3,500	2	4	5	..	..	..	....
Salamander	do	735	19.5	2,500	3,500	2	4	5	..	..	..	....
Jaseur	do	810	19.8	2,500	3,500	2	4	3	..	..	..	....
Gossamer	do	735	19.5	2,500	3,500	2	4	5	..	..	..	....
Gleaner	do	735	19.5	2,500	3,500	2	4	5	..	..	..	....
Spider	do	525	19	1,600	2,700	1	6	4	..	..	..	....
Rattlesnake	do	550	18.5	1,600	2,700	1	6	4	..	..	..	....
Total "A" Fleet	20 ships	79,440	.....	105,200	146,000	132	243	93	1	..	1	3
"B" FLEET												
Anson	Battleship	10,600	16.7	7,500	11,500	10	28	5	..	1	1	2
Thunderer	do	9,330	13.4	5,500	7,000	4	18	4	..	..	..	....
Rupert	Coast-def. vessel	5,440	14.4	4,500	6,000	4	19	4	..	..	..	....
Immortalité	Armored cruiser	5,600	18.5	5,500	8,500	12	18	6	..	..	..	....
Tribune	Protected cruiser	3,400	20	7,000	9,000	8	13	4	..	..	..	....
Iphigenia	do	3,600	19.7	7,000	9,000	8	13	4	..	..	..	....
Latona	do	3,400	20	7,000	9,000	8	13	4	..	..	..	....
Mersey	do	4,050	18	4,000	6,000	12	15	6	..	..	..	....
Iris	do	3,730	18	6,000	6,000	13	6	4	..	..	..	....
Bellona	do	1,830	16.5	3,200	3,600	6	6	2	..	..	..	....
Barracouta	do	1,580	16.5	1,750	3,000	6	6	2	..	..	..	....
Sheldrake	do	735	19.5	2,500	3,500	2	4	5	..	..	..	....
Grasshopper	do	525	19	1,600	2,700	1	6	4	..	..	..	....
Total "B" Fleet	13 ships	53,820	.....	63,050	84,800	94	165	54	..	1	1	2
Total *Red*	33 ships	133,260	.....	168,250	230,800	226	408	147	1	1	2	5
"C" FLEET.												
ALEXANDRA	Battleship	9,490	15	7,000	8,000	18	14	4	..	1	1	2
SUPERB	do	9,170	13.5	6,000	8,500	22	20	4	..	..	..	....
BENBOW	do	10,600	16.7	7,500	11,500	12	21	5	..	..	..	....
AUDACIOUS	do	6,010	13.2	3,300	4,830	18	14	4	..	..	..	....
AUSTRALIA	Armored cruiser	5,600	18.5	5,500	8,500	12	20	4	..	..	..	....
GALATEA	do	5,600	18.5	5,500	8,500	12	16	6	..	..	..	....

Officers.																							
						Royal Naval Reserve.					Pay Corps.				Marines.		Warrant officers.			For coaling.				
Captains.	Commanders.	Staff commanders.	Lieutenants.	Sublieutenants.	Midshipmen.	Lieutenants.	Sublieutenants.	Midshipmen.	Naval constructors.	Surgeons.	Paymasters.	Clerks.	Engineers.	Chaplains and naval instructors.	Artillery.	Infantry.	Gunners.	Boatswains.	Carpenters.	Retired commanders.	Retired lieutenants.	Total officers.	Petty officers and men.	Value assigned for the maneuvres.
1	2	....	7	5	11	1	3	..	2	2	2	2	7	2	1	2	2	3	1	1	....	62	713	12
1	1	....	6	2	8	1	..	..	1	2	2	1	5	1	..	1	1	2	1	....	....	36	529	12
1	1	1	5	1	....	1	..	..	..	1	1	1	4	1	1	1	2	2	1	....	....	25	568	12
1	1	1	4	1	....	1	..	..	..	2	2	....	4	....	..	1	1	3	1	....	....	23	335	12
1	1	....	5	2	7	1	..	..	..	2	2	....	4	1	..	1	2	2	1	....	....	32	483	12
1	1	....	6	1	....	1	..	..	..	2	2	....	6	1	..	1	1	2	1	....	....	26	550	12
1	....	....	4	1	....	....	..	..	..	1	1	1	3	....	..	..	2	....	1	....	....	15	272	4
1	....	....	3	2	....	....	..	..	..	1	1	....	3	....	..	..	1	1	1	....	....	14	272	4
1	..	1	2	1	....	1	..	..	..	1	1	1	3	....	..	..	2	1	1	....	....	16	272	4
1	....	....	4	1	....	....	..	..	..	1	1	....	3	....	..	..	2	1	1	....	....	15	272	4
1	....	....	4	1	....	....	..	..	..	1	1	1	3	....	..	..	2	1	1	....	....	16	272	4
1	....	....	3	2	....	....	..	..	..	1	1	....	3	....	..	..	1	1	1	....	....	14	272	4
....	....	....	3	....	....	....	..	..	..	1	....	....	2	....	..	..	1	....	....	....	....	7	92	1
....	1	....	....	2	....	....	..	..	..	1	....	....	2	....	..	..	....	....	....	....	....	6	92	1
....	1	....	....	2	....	....	..	..	..	1	....	....	2	....	..	..	....	....	....	....	....	6	92	1
....	1	....	....	2	....	....	..	..	..	1	....	....	2	....	..	..	....	....	....	....	....	6	92	1
....	1	....	....	2	....	....	..	..	..	1	....	....	2	....	..	..	....	....	....	....	....	6	92	1
....	1	....	....	2	....	....	..	..	..	1	....	....	2	....	..	..	....	....	....	....	....	6	92	1
....	....	....	1	2	....	....	..	..	..	1	....	....	1	....	..	..	....	1	....	....	....	6	67	1
....	....	....	1	2	....	....	..	..	..	1	....	....	1	....	..	..	....	....	....	....	....	5	67	1
12	12	3	58	34	26	7	3	..	3	25	17	7	62	6	2	7	20	20	12	1	....	342	5,496	104
1	1	1	5	5	11	2	....	..	1	2	2	1	6	2	..	1	2	2	1	....	1	51	536	12
1	1	1	4	1	....	1	..	..	..	1	1	1	4	1	..	1	3	2	1	....	....	24	513	12
1	1	1	3	1	....	....	..	..	..	2	2	....	3	....	..	..	1	4	1	....	....	20	232	12
1	1	....	5	2	8	1	..	..	..	2	2	....	4	1	1	..	1	2	1	....	....	32	483	12
1	....	1	2	2	....	....	..	..	..	1	1	....	3	....	..	..	2	....	1	....	....	14	272	4
1	....	....	4	1	....	....	..	..	..	1	1	1	3	....	..	..	2	1	1	....	....	16	272	4
1	....	....	4	1	....	....	..	..	..	1	1	1	3	....	..	..	2	1	1	....	....	16	272	4
1	1	....	5	1	....	1	..	..	..	2	2	....	3	....	..	..	1	4	1	....	....	22	326	4
1	....	1	4	1	....	1	..	..	..	1	2	....	4	....	..	..	2	2	1	....	....	20	291	4
....	1	....	3	....	....	....	1	..	..	1	1	....	2	....	..	..	1	....	....	....	....	10	168	4
....	1	....	3	1	....	....	..	..	..	1	1	....	2	....	..	..	1	....	1	....	....	11	160	1
....	1	....	....	2	....	....	..	..	..	1	....	....	2	....	..	..	....	....	....	....	....	6	92	1
....	....	....	1	2	....	....	..	..	..	1	....	....	1	....	..	..	....	....	....	....	....	5	67	1
9	8	5	43	20	19	6	1	..	1	17	16	4	40	4	1	2	18	18	10	....	1	247	3,684	75
21	20	8	101	54	45	13	4	..	4	42	33	11	102	10	3	9	38	38	22	1	1	589	9,180	179
1	2	....	6	6	....	1	3	2	..	2	3	....	4	1	2	1	2	3	1	....	1	45	689	12
1	2	....	4	1	....	1	..	..	..	2	1	1	4	1	..	2	1	3	1	....	....	25	651	12
1	1	1	5	1	....	1	..	..	..	2	2	....	5	1	..	1	2	1	1	....	....	25	559	12
1	1	....	5	1	....	1	..	..	..	2	1	1	2	1	1	2	3	2	1	....	....	25	489	12
1	2	....	4	1	....	1	..	..	..	2	2	....	4	1	..	1	1	2	1	....	....	23	483	12
1	2	....	4	1	....	1	..	..	..	2	2	....	4	1	..	1	3	2	1	....	....	25	483	12

Name of ship.	Class.	Displacement.	Maximum speed.	I. H. P.		Battery.			Admirals and staff.			
				Natural draft.	Forced draft.	Guns, main.	Guns, secondary.	Torpedo tubes.	Vice-admiral.	Rear-admirals.	Flag lieutenants.	Secretaries and clerks.
"C" FLEET—Continued.		*Tons.*	*Knots*									
TERPSICHORE	Protected cruiser	3,400	20	7,000	9,000	8	13	4	..	..	..	....
INDEFATIGABLE	....do	3,600	19.7	7,000	9,000	8	13	4	..	..	..	....
MELAMPUS	....do	3,400	20	7,000	9,000	8	13	4	..	..	..	....
ÆOLUS	....do	3,600	19.7	7,000	9,000	8	13	4	..	..	..	....
SPARTAN	....do	3,600	19.7	7,000	9,000	8	13	4	..	..	..	....
Total "C" Fleet	11 ships	64,070	.....	69,800	94,830	134	170	47	..	1	1	2
"D" FLEET.												
SWIFTSURE	Battle ship	6,910	13.7	3,500	4,260	18	20	4	..	1	1	2
HERO	....do	6,200	15.5	4,500	6,000	6	21	5	..	..	..	....
AURORA	Armored cruiser	5,600	18.5	5,500	8,500	12	18	0	..	..	..	....
ANDROMACHE	Protected cruiser	3,400	20	7,000	9,000	8	13	4	..	..	..	....
APOLLO	....do	3,400	20	7,000	9,000	8	13	4	..	..	..	....
BRILLIANT	....do	3,600	19.7	7,000	9,000	8	13	4	..	..	..	....
RETRIBUTION	....do	3,600	19.7	7,000	9,000	8	13	4	..	..	..	....
FORTH	....do	4,050	18	3,800	5,700	12	13	6	..	..	..	....
THAMES	....do	4,050	18	3,800	5,700	12	13	0	..	..	..	....
PEARL	....do	2,575	19	4,500	7,500	8	12	4	..	..	..	....
Total "D" Fleet	10 ships	43,385	.....	53,600	73,660	100	149	47	..	1	1	2
"COAST OF IRELAND SQUADRON."	.....	.....	.....	.....	.....	....	....	....	..	1	1	2
BARROSA	Protected cruiser	1,580	16.5	1,750	3,000	6	6	2	..	..	..	....
JASON	Torpedo vessel	810	19.8	2,500	3,500	2	4	3	..	..	..	....
CIRCE	....do	810	19.8	2,500	3,500	2	4	5	..	..	..	....
SEAGULL	....do	735	20	2,500	3,500	2	4	5	..	..	..	....
VULCAN	Torp. depot ship	6,620	18.5	7,200	12,000	8	12	6	..	..	..	....
CURLEW	Gun vessel	950	14.5	850	12,000	4	8	3	..	..	..	....
MAGNET	Special serv. vessel	430	11	650	650	0	0	0	..	..	..	....
TRAVELLER	....do	700	15	1,000	1,000	0	4	0	..	..	..	....
HEARTY	....do	1,300	16	2,100	2,100	2	2	0	..	..	..	....
RAVEN	Gun vessel	465	9.5	460	460	4	2	0	..	..	..	....
WILD SWAN	Cruiser	1,130	10.3	1,090	1,090	8	6	0	..	..	..	....
24 torpedo boats	.....	2,052	.....	.....	23,294	0	67	99	..	..	..	....
Total "COAST OF IRELAND SQUADRON."	11 ships, 24 torpedo boats.	17,582	.....	.....	55,294	38	119	123	..	1	1	2
Total BLUE	32 ships, 24 torpedo boats.	125,037	.....	.....	223,784	272	438	217	..	3	3	6
Grand Total *Red* and BLUE.	65 ships, 24 torpedo boats.	058,297	.....	.....	454,584	498	846	364	1	4	5	11

Officers.																								
						Royal Naval Reserve.					Pay Corps.				Marines.		Warrant officers.			For coaling.				
Captains.	Commanders.	Staff commanders.	Lieutenants.	Sublieutenants.	Midshipmen.	Lieutenants.	Sublieutenants.	Midshipmen.	Naval constructors.	Surgeons.	Paymasters.	Clerks.	Engineers.	Chaplains and naval instructors.	Artillery.	Infantry.	Gunners.	Boatswains.	Carpenters.	Retired commanders.	Retired lieutenants.	Total officers.	Petty officers and men.	Value assigned for the manœuvres.
1	....	....	4	1	....	....	....	....	....	1	1	1	3	....	....	....	2	....	1	....	....	15	272	4
1	....	....	4	1	....	....	....	....	....	1	1	....	3	....	....	....	1	2	1	....	....	15	272	4
1	1	....	4	1	....	....	....	....	....	1	1	1	3	....	....	1	1	3	1	....	....	19	272	4
1	....	....	4	1	....	....	....	....	....	1	1	....	3	....	....	....	2	1	1	....	....	15	272	4
1	....	....	3	2	....	....	....	....	....	1	1	1	3	....	....	....	1	1	1	....	....	15	272	4
11	11	1	47	17	....	6	3	2	....	17	16	5	38	6	3	9	19	20	11	....	1	247	4,705	92
1	2	....	3	4	....	2	1	....	....	2	1	1	2	1	....	3	2	3	1	1	....	34	506	12
1	1	1	4	1	....	1	....	....	....	2	2	....	4	....	....	1	1	4	1	....	....	24	335	12
1	1	1	5	1	....	....	....	....	....	2	1	1	4	1	....	1	1	3	1	....	....	24	483	12
1	....	....	4	1	....	....	....	....	....	1	1	1	3	....	....	....	2	....	1	....	....	15	272	4
1	....	....	4	1	....	....	....	....	....	1	1	1	3	....	....	....	1	1	1	....	....	15	272	4
1	....	....	4	1	....	....	....	....	....	1	1	1	3	....	....	....	1	1	1	....	....	15	272	4
1	....	....	4	1	....	....	....	....	....	1	1	1	3	....	....	....	1	1	1	....	....	15	272	4
1	1	1	3	1	....	1	....	....	....	1	2	....	3	....	....	2	1	2	1	....	....	19	324	4
1	1	....	4	1	....	1	....	....	....	1	1	1	3	....	....	1	1	2	1	....	....	19	324	4
1	....	....	3	1	....	....	....	....	....	1	1	....	2	....	....	....	1	....	1	....	....	11	216	4
10	6	3	38	13	....	5	1	....	....	13	12	7	30	2	....	7	12	17	10	1	....	191	3,276	64
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4	....	....
....	1	....	3	1	....	....	....	....	....	1	1	....	2	....	....	....	1	....	1	....	....	11	160	1
....	1	....	....	2	....	....	....	....	....	1	....	....	2	....	....	....	....	....	....	....	....	6	92	1
....	1	....	2	....	....	....	....	....	....	1	....	....	2	....	....	....	....	....	....	....	....	6	92	1
....	....	....	1	2	....	....	....	....	....	1	....	....	2	....	....	....	1	....	....	....	....	7	92	1
1	....	....	6	....	....	1	....	....	....	2	2	....	5	....	....	....	2	4	1	....	....	24	387	0
....	1	....	3	....	....	....	....	....	....	1	1	....	1	....	....	....	1	....	....	....	....	8	103	0
....	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	3	56	0
....	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	56	0
....	1	....	2	....	....	....	....	....	....	1	1	....	1	....	....	....	....	4	....	....	....	10	60	0
....	....	....	1	2	....	....	....	....	....	1	1	....	1	....	....	....	1	....	....	....	....	7	60	0
....	1	....	3	....	....	....	....	....	....	1	1	....	1	....	....	....	1	1	1	....	....	9	140	0
....	....	....	13	18	....	....	....	....	....	....	....	....	....	....	....	....	20	4	....	....	....	55	386	0
1	6	....	37	26	....	1	....	....	....	10	7	....	17	....	....	....	28	12	3	....	....	152	1,684	4
22	23	4	122	56	....	12	4	2	....	40	35	12	85	8	3	16	59	49	24	1	1	590	9,665	160
43	43	12	223	110	45	25	8	2	4	82	68	23	187	18	6	25	97	87	46	2	2	1,179	18,845	359

TWENTY-FOUR TORPEDO BOATS OF "COAST OF IRELAND SQUADRON".

Name of boat.	Length.	Displacement.	Maximum speed.	Maximum I. H. P.	Armament. 3-pounder R. F. G.	Armament. Torpedo tubes.	Officers. Lieutenants.	Officers. Sub-lieutenants.	Officers. Gunners.	Officers. Boatswains.	Total officers	Petty officers and men.	Date of launch.
	Feet.	*Tons.*	*Knots.*										
No. 34	125	85	18.8	968	2	5	1	....	1	....	2	15	1886
45	125	64	19	750	2	4	....	1	1	....	2	15	1887
52	125	64	19	750	2	4	....	1	1	....	2	15	1887
53	125	64	19	750	2	4	....	1	1	....	2	15	1887
57	125	64	19	750	2	4	....	1	1	....	2	15	1887
58	125	64	19	750	2	4	1	....	1	....	2	15	1887
59	125	64	19	750	2	4	1	....	1	....	2	15	1887
60	125	64	19	750	2	4	....	1	1	....	2	15	1887
63	130	90	23.2	1,100	3	5	....	1	1	....	2	16	1886
64	130	90	23.2	1,100	3	5	....	1	1	....	2	16	1886
66	130	90	23.2	1,100	3	5	....	1	1	....	2	16	1886
67	130	90	23.2	1,100	3	5	1	....	1	....	2	16	1886
68	130	90	23.2	1,100	3	5	....	1	....	1	2	16	1886
72	130	90	23.2	1,100	4	5	1	....	1	....	2	16	1886
73	130	90	23.2	1,100	3	5	....	1	....	1	2	16	1886
77	130	90	23.2	1,100	3	5	....	1	....	1	2	16	1886
79	130	90	23.2	1,100	3	5	1	....	1	....	2	16	1886
80	135	102	23	1,539	3	3	1	1	1	....	3	21	1887
81	150	125	20.8	1,387	5	3	1	1	1	....	3	21	1887
82	130	96.5	22.5	1,150	3	3	1	1	1	....	3	16	1889
83	130	96.5	22.6	1,150	3	3	1	1	1	....	3	16	1889
84	130	96.5	22.6	1,150	3	3	1	1	....	1	3	16	1889
85	130	96.5	23	1,150	3	3	1	1	1	....	3	16	1889
87	130	96.5	23	1,150	3	3	1	1	1	....	3	16	1889
Total		2,052		23,294	67	99	13	18	20	4	55	386	

The following statement of the number of ships of all classes, using the present British classification engaged in the naval manœuvres of the past 7 years may be found interesting:

	1887.	1888.	1889.	1890.	1891.	1892.	1893.
Battle ships:							
First-class	1	3	5	4	6	6	4
Second-class	5	4	4	3	3	3	3
Third-class	6	6	6	6	7	7	4
Coast-defense vessels	9	3	9	7	2	6	1
Cruisers:							
First-class	5	6	11	9	5	6	7
Second-class	9	12	9	8	7	14	23
Third-class	3	6	12	10	11	6	3
Gun vessels, first-class	3	5	8	6	11	13	14
Torpedo boats	38	24	38	24	20	27	24
Other craft	30	.....	10	3	4	4	6
Total	109	69	112	80	76	92	89

The tonnage, horse power, and men engaged this year were respectively 258,297, 454,584, and 20,024; last year they were 283,280, 384,590, and 20,042; and in 1887, 232,687, 246,410, and 16,227. Last year the average horse power of each ship engaged was 4,180; in 1887 it was only 2,260; while this year it was 5,108. Last year was particularly remarkable for the fine squadron of second-class cruisers, 14 in number, aggregating 50,980 tons, and representing 111,230 horse power. It also stood alone as a show of first-class gun vessels; but this year's fleet was better in both these important respects, containing 23 second-class cruisers, aggregating 81,455 tons displacement and 192,900 horse power, and 14 first-class gun vessels of 10,125 tons and 44,300 horse power, against 13 last year of 9,165 tons and 40,800 horse power.

The preliminary cruise was a necessary preparation for the work to follow, and barely sufficient, but would have been wholly inadequate if the petty officers and men had not been already well trained and prepared to drop into their places on board the ships to which they found themselves assigned. The anomaly of a green crew of merchant seamen and landsmen leavened with a few trained men was not seen on any ship of this modern fleet. With crews of men lacking a previous complete man-of-war training it would have been impossible to work the 89 vessels of all classes into efficient fighting fleets in twice as many weeks as there were days employed. A general naval action in the present well-prepared state of the great naval powers would probably follow soon after such outbreak. Casualties to ships as well as men would be numerous, other ships would be required to immediately fill the vacancies, and the side which could first bring its reserve forward ready to go into action would have an advantage hard to withstand whatever might be the eventual relative strength of the opposing forces.

Even with the trained crews which manned the ships of these fleets constant drill at stations for the many possibilities of war was necessary and the good results are reported to have been very apparent. The training of commanding officers, deck officers, engineers, quartermasters, and signalmen in squadron cruising is an important element in fleet efficiency, and its good effect was shown in the great improvement in keeping station manifest at the end of the week. The "*A*" and "*B*" fleets were naturally the more efficient in this respect, as they contained the 7 ships of the Channel Squadron, already well trained in cruising together. Their evolutions demonstrated the advantage possessed by a well-practiced fleet, and that steam tactics in peace time are an absolute necessity of readiness for war. The signal force of all the fleets appears to have been inefficient and was the cause of much complaint and some confusion. This appears to have been particularly the case with the torpedo vessels, on some of which it is reported to have been impossible to have signals read correctly and quickly. The deficiency is a serious one, and appears to have been recognized, as additional signal men and boys were detailed to the fleet from the train-

ing stations; but their inexperience caused delay and at times was a source of danger. The *Royal Sovereign* carried 52 signal men and boys and the *Rodney* 11, afterwards increased to 16.

Among the weak points in the composition of the fleets brought out during the week, the torpedo vessels were found to be disappointing and unreliable. Though credited with a speed of 19 to 19.8 knots, they failed to keep up a speed of 5 knots less, the *Niger*, the newest, and presumably the best, of the lot, failing to keep company with the *Royal Sovereign*, going 14 knots in smooth water, and it is noticeable that only three of them were credited by the umpires after the manœuvres with doing what they were presumably designed for, catching torpedo boats or putting them out of action. The *Rattlesnake*, the oldest, one of the smallest, and officially the slowest, of the lot, is credited with being the most efficient and reliable for speed.

The *Nelson* was the weakest link in "*A*" fleet, as she could not maintain over 12 knots speed; the *Rodney*, with a foul bottom from infrequent docking, could make about 13.5, and the *Thunderer*, of "*B*" fleet, could make about 13 knots. The *Anson* and *Rodney*, as was known of their class, could not fight their forward guns in any but a smooth sea, the decks in a head sea being awash up to the forward barbettes. Under the same conditions the low freeboard *Conquerer*, *Thunderer*, and *Rupert* took green seas over their decks, while water broke over their turrets in such quantities as to often make it impracticable to fight their turret guns.

Of "C" fleet, the AUDACIOUS was the poorest, being with difficulty kept in station even at the low speed of 11 knots. The BENBOW exhibited her tendency to pitch heavily, and took seas over her bows when the other ships were fairly steady gun platforms. The HERO was the poorest of "D" fleet.

The main points developed were: The insufficient personnel; the necessity of a larger force of care-takers on the ships in reserve; the need of more frequent docking of unsheathed ships; the advisability of more training with arms up to date of the coast guardsmen; the absolute danger of an inefficient signal force; the mistake of associating old-type armored vessels of low speed, such as the *Nelson* and AUDACIOUS, with a modern fleet of battle ships whose movements they must hinder without much compensation in strength; that seagoing torpedo boats or efficient gunboats which can be relied upon for high speeds are a necessary accompaniment for a fleet off a hostile coast harboring torpedo-boat flotillas; in short, that more officers and trained men, homogeneous fleets of good speed, numerous swift scouts, a better type of torpedo-boat catchers, and a properly trained and distributed signal force are prime necessities.

Since the manœuvres the first reserve of ships has been strengthened by substituting the *Inflexible* for the *Nelson*, at Portsmouth; the *Devastation* for the SWIFTSURE, at Devenport; the *Colossus* for the *Neptune*,

at Holyhead, and the *Warspite* for the *Triumph*, at Queenstown. The torpedo vessels which gave so little satisfaction are to be made available in the first reserve by attaching them as tenders to the coast guard ships, the *Niger* having already been assigned to the GALATEA, replacing a worn-out obsolete vessel. A new type of small torpedo-boat catchers of very high speed is being rapidly added to the navy in large numbers to do the work for which the gunboats referred to proved so inefficient during the manœuvres, when much new and instructive light was thrown on the great danger from hostile torpedo boats properly handled.

Some complaint was made of the bad arrangements of the colliers retarding the work of coaling, though the *Royal Sovereign*, using a collier with patent "transporters," was enabled to fill up quickly at the average rate of about 75 tons an hour.

The bunker arrangement of some of the cruisers is bad, notably the *Blenheim*, whose upper bunker service was said to interfere with the ammunition supply. Much valuable experience was gained in coaling, and it was practically demonstrated that the "transporter" referred to is the most successful device yet tried for coaling directly from a collier's hold. The advantage of having the several collier fleets under the control of experienced commanders and lieutenants was very manifest. A comparison of the rates of coaling of the different classes of vessels as shown in the following tabulated performance of "*B*" fleet at Lamlash may be interesting:

	Amount.	Average per hour	Time.
	Tons.	*Tons.*	*Hours.*
Thunderer	159	17.60	9
Tribune	114	16.30	7
Anson	310	51.65	6
Latona	120	24	5
Iris	140	12.75	11
Barracouta	79	11.30	7
Bellona	88	17.60	5
Sheldrake	36	7.20	5
Grasshopper	38	7.60	5
Iphigenia	100	20.25	4.40
Mersey	170	28.30	6
Immortalité	200	29.70	6.45
Rupert	167	28	5.50

In the daily drills of the crews the influence of the late *Victoria* disaster was evident in the particular attention paid to working the water-tight doors and drilling at stations for "collision and grounding."

As indicated in section 2 of the general orders and assigning the tactical values to the ships engaged, the *Red* side had a value of 179 as opposed to the BLUE side's 160; but BLUE "C" fleet had a value of 92, while *Red* "*B*" had only 75, and *Red* "*A*," with 104 points, was larger

than either "C" or "D" separately, but less than the 156 of "C" and "D" combined. Although the rules governing the manœuvres have not been published, enough has been made public to enable an idea to be formed of the scheme.

In action a superiority of 12.5 per cent maintained at a specified distance for a specified time is decisive of victory. Fire is not to be opened at a greater distance than 4,000 yards from ships, and the distance of 4,000 yards between ships in action must not be exceeded nor must it fall below 8 cables, or 1,920 yards. Squadron engagements must last 2 hours; if indecisive both sides are out of action for 24 hours; if decisive the beaten side to go into port and await further instructions. Single vessels decisively beaten are out of action for 48 hours. Ships out of action hoist commercial "B" at the main and show position lights at night. Single-ship actions must last 1 hour unless a great preponderance of force of one side. Torpedo boats must not discharge torpedoes at a range greater than 500 yards, and are then out of action until they reach a friendly port. Fire on them is not to be opened at range greater that 2,000 yards by day and 1,000 yards by night, and to put them out of action 15 aimed shots must be fired at them in the first case and 30 in the second. Vessels actually struck by a torpedo before the requisite number of aimed shots have been fired to be out of action for 48 hours. Torpedo-boat numbers not to be obscured nor altered in any way. Claims to be telegraphed to umpires as soon as possible. Umpires' decisions are final, and no reasons for decisions need be given. Decisions to be communicated as soon as possible to the contending admirals. Nothing that is not permissible or practicable in time of war is allowed. Colliers are not liable to capture. Torpedoes, 10 to each boat, fitted with callapsible heads; other torpedoes not to be used. Torpedo-gun vessels may not be fired at with torpedoes. Torpedo boats when out of action to return to their own ports displaying distinguishing signal.

All vessels of group *a* are given an equal value of 12, and are classed together as first-class battle ships, although actually composing an heterogeneous assemblage of battle ships of three classes, coast-defense vessels, and armored cruisers. Similarly all vessels of group *b* were classed together as second-class cruisers having a value of 4, and with two exceptions were what they were supposed to be. Group *c* comprised all the torpedo vessels and 2 light cruisers having equal value of 1.

For manœuvre purposes Ireland was practically converted into a promontory by provisions ot section 3 of the general orders establishing a "forbidden belt" between the two BLUE fleets, which was not to crossed by vessels of either side after the first week of preliminary exercises. This artificial geographical formation, together with the distribution of the fleets and torpedo-boat squadron, have caused analogies to be drawn between the scheme of the manœuvres and a state of

war between Great Britain and France, "*A*" and "*B*" representing the two British fleets at Portsmouth and Plymouth, "C" and "D" the French fleets at Cherbourg and Brest, respectively, and the "COAST OF IRELAND SQUADRON" the torpedo-boat flotillas stationed along the northwest coast of France. The advantage contended for, the control of the Irish Sea, was supposed to represent the English Channel. Another analogy has separated the fleets more widely, and compared "*A*" and "*B*" with the British Mediterranean and channel fleets, "C" and "D," with the French Toulon and northern fleets, the North channel representing the west end of the English Channel, St. George's Channel the Straits of Gibraltar, and the control of the Irish Sea representing, as in the first case, that of the English Channel.

The *Red* side was required by section 2 to bring the BLUE side to action, and to obtain command of the Irish Sea. If both sides came together with their strength intact, a decisive action was impossible, as *Red* lacked by 1 point the necessary strength of having a superiority of 12.5 per cent over the 160 points of BLUE. If, however, BLUE should neglect to join the 4 points of the "COAST OF IRELAND" gunboats to his fleets, then *Red* would have the necessary superiority for attaining his object. If "C" could meet "*B*" before "*A*" and keep it in action an hour, the task of *Red* becomes hopeless; but if "*A*" could meet "C" before the latter joins "D" the object of *Red* is accomplished. The problem would seem simpler for BLUE than for *Red*, as "C" was but 380 miles from "*B*" at the opening of hostilities, while "*A*" was 460 miles from its ally, and if "*B*" should pursue the only practicable course and come south, probable success would lie with whichever side succeeded in getting its southern fleet first across a line between St. Davids Head on the Welsh coast and Carnsore Point on the Irish coast. This line is 168 miles from "C" at Bantry Bay and 228 miles from "*A*" at Torbay. It was known that the AUDACIOUS, the slowest of "C," could make but 11 knots, and 15.5 hours would be needed by that fleet to cover the distance. It was known also that the *Nelson* and *Conquerer* of "*A*" could make about 13 knots, and could not probably keep up over 12 knots, at which rate it would take 19 hours to reach the line. This would give "C" about 3.5 hours' start over the line, and if properly served by her cruisers and those of her ally "D" it would seem possible to pick up "*B*", defeat him, proceed north, join "D," and then seek and defeat "*A*." It would be impracticable for "*B*" to wait to attack "D" in the narrow waters between Larne and Port Patrick, where the sea contended for begins, exposed to attacks from the torpedo flotillas stationed at Larne, Belfast Loughs, and Carlingford, and the movement of that fleet south to join its ally could be counted upon as a certainty. Should "C" fail to intercept "*B*," it needed only to continue north, meet "D" and the gunboats from the "COAST OF IRELAND," where its defeat by the combined *Red* fleets became impossible. This is practically what happened, though "C" undoubtedly owed its safety

from the combined *Reds* to the fog of July 28, an action being fought on the 29th, which was indecisive, not through the presence of the "COAST OF IRELAND" gunboats with BLUE, but the absence of a material part of *Red*. Without the official rules it is difficult to understand why the "*A*" admiral was allowed to use the *Blenheim* and *Narcissus*, classed as battle ships, before war was declared, under the permission for cruisers to reconnoiter, and the "*B*" admiral to use the *Immortalité* in the same way. Also, it does not appear why the "*A*" battle ships were allowed to steam off from the vicinity of their rendezvous at 6:20 p. m. on the 27th, when war was declared to begin at 10 p. m., until which hour the battle ships of the other fleets were kept in port. This gave "*A*" the advantage of 3.5 hours' start over "C," practically equalizing the distances to the objective point, St. George's Channel, from their respective rendezvous, taking into consideration the known speeds of the slowest ships of each fleet.

The scouting of the cruisers appears to have been not of sufficient value to their fleets. The gunboats did not hinder the raids of torpedo-boat flotillas, while the latter proved their great value either as adjuncts to a fleet on the defensive or as raiders operating from a home base against near-by hostile harbors. The first engagement was a spectacular success and interesting, as it was the largest body of modern war ships that has manœuvred together as if engaged. Cruisers and torpedo vessels have a definite value and should have a definite place in a fleet action. To develop their full worth they might be organized under senior captains or junior flag officers, who would withdraw them when the opposing lines of battle got touch and be responsible for handling them to the best advantage as opportunity offered. Admirals commanding lines of battle have quite enough to engage their full attention without the distraction of directing the operations of light craft in action. The tactics of the second engagement were more practical.

The *Red* fleet undoubtedly failed of its objects to gain command of the Irish Sea.

Umpires' decisions.

Class of vessel.	"Out of action."		
	Belonging to *Red* side.	Belonging to BLUE side.	Total.
Battle ships, etc., group *a*	1	None	1
Cruisers, etc., group *b*	6	3	9
Catchers, etc., group *c*	3	None	3
Torpedo boats	None	24	24

The decisions in detail were as follows:

The losses to *Red* by action of the enemy during the 8 days of hostilities, from 10 p. m., July 27, to 6 p. m., August 4, were:

Tribune out of action by No. **44** a. m. July 28.
Thunderer out of action by No. **41** a. m. July 28.
Sappho out of action by No. **72** p. m. July 28.
Thetis out of action by No. **58** p. m. July 28.
Pique out of action by No. **57** p. m. July 28.
Speedwell, *Skipjack*, *Spider* } out of action by BRILLIANT p. m. July 31.
A second-class cruiser out of action by No. **52** p. m. August 3.
A second-class cruiser out of action by No. **53** p. m. August 3.

BLUE'S losses during the same interval were:

No. **86** out of action by *Narcissus* p. m. July 27.
FORTH out of action by No. **83**, an ally, p. m. July 27.
1 second-class torpedo boat out of action by *Sheldrake* p. m. July 28.
4 first-class torpedo boats, 2 second-class torpedo boats } out of action by "*B*" fleet a. m. July 28.
No. **63** out of action by *Red* fleet a. m. July 29.
1 first-class torpedo boat out of action by *Gossamer* and *Gleaner* a. m. July 29.
MELAMPUS out of action by Nos. **83**, and **87**, allies, p. m. July 31.
Nos. **64**, and **67** out of action by *Iphigenia* p. m. July 31.
APOLLO out of action by *Blenheim* and 3 consorts p. m. August 1.
Nos. **64**, **67**, and **72** out of action by *Narcissus* a. m. August 1.
Nos. **45**, **52**, **53**, and **79** out of action by *Bellona* p. m. July 31.
Nos. **63**, **66**, and **77** out of action by *Rattlesnake* a. m. August 2.
No. **58** out of action by *Narcissus* p. m. August 2.
No. **34** out of action by *Rattlesnake* p. m. August 3.
Nos. **45** and **79** out of action by *Red* fleet p. m. August 3.
1 first-class torpedo boat out of action by *Speedwell*, *Skipjack*, and *Spider* a. m. August 4.

From this summary the good work done by the topedo boats is plainly seen. They destroyed under service conditions a battle ship of the enemy and 6 cruisers, approximately valued at $10,000,000, and manned by about 2,000 men, while risking only 24 boats, of an approximate value of $2,000,000, manned by about 400 men. Twenty-four first-class boats were allowed by the umpires to *Red*, but of these Nos. *63*, *64*, *45*, *79*, and *67* are allowed twice. The fact that 2 cruisers were torpedoed by their allies emphasizes the necessity for great watchfulness and prompt use of private signals in time of war, as torpedo boats can not be expected to take the chances of being too circumspect in the presence of a possible enemy.

CASUALTIES.

The manœuvres developed the weakness of certain types of boilers and engines and the tendency of some of the steering gear to give trouble. The other mishaps were not excessive in number, and as a rule were unimportant.

On July 11, a torpedo boat going out of Portsmouth collided with a

cargo boat under sail and returned to the dockyard for slight repairs, but got away again the following day. At Chatham, No. **64**, leaving the basin under full steam, collided with a second-class cruiser, not mobilized, lying at a buoy, partially smashing the bow of the torpedo boat and punching a hole in the side of the cruiser. The boat went to Sheerness and was repaired by the following evening. The *Conqueror*, having left Plymouth at noon, proceeded to Portland, and while mooring broke the crown wheel of capstan engine, and was obliged to return to Devonport dockyard, where repairs were at once taken in hand. They were completed on July 22, when she left and joined her fleet at sea cruising. On July 12, at Sheerness, No. **68** on leaving fouled moorings, requiring a diver to clear the screws, which were found bent and some plates dented, necessitating docking at Chatham. The work was done during the night, and she got away on the 13th. A steam cutter of the BRILLIANT ran on the ram of a torpedo boat and tore a hole in her bottom. The boat was repaired and ship got away on 13th. At Plymouth the *Rainbow*, making her 1-hour engine trials, fractured a bracket, carried away the centrifugal lubricator, and heated one of the low-pressure crank heads. Repairs were made by the dockyard force, and she got away on the evening of the 13th; on August 1, after chasing an enemy, 1 engine was disabled, the brasses having run. The *Pique* developed a crack in one of her furnaces during the trial after commissioning, but by order of the commander-in-chief proceeded to join the squadron. Later, during the preliminary cruise, the same defect appeared, necessitating her dropping out of the fleet for awhile. On the contractors' trial one year ago a similar mishap occurred and the cracked furnaces were then replaced by new ones. Leaky steam pipes required repairs on the 24th, which were completed by noon of the 25th.

The *Jaseur* had an unsatisfactory trial at Sheerness, which was renewed on July 13, but was given up after an hour, and the vessel returned to her port totally disabled, with the port low-pressure cylinder cracked. A new one had to be cast, requiring two or three months' time. The *Niger*, a sister ship, was ordered to take her place, and, although a new ship, not expected to be completed for a month, the *Jaseur's* crew were on board of her by July 19, and she left for her fleet on the 20th, after a steam trial of 2 hours. The *Gossamer* developed leaky tubes, and was detained at Chatham to ferrule them and to make good defects developed in the electric plant. These repairs were completed by July 19, and she left Sheerness the following day to join her fleet. The *Barracouta*, leaving Sheerness July 13, grounded near the entrance to the Medway River, but was got off in a few hours with the aid of tugs, and left to join her fleet apparently undamaged. During the night of July 13, No. **87** returned to Plymouth from Falmouth in tow of the TRAVELLER, special-service vessel, with a damaged screw and shaft; was docked, defects made good, and left the following day for her fleet. The MELAMPUS joined her fleet at Torbay the evening of July 13, and reported trouble with an

old defect in a boiler, which had been repaired several months previously. A crack developing, she was ordered to Devenport on the morning of July 17, when starting for the preliminary cruise with the fleet. Caulking and a patch were needed and cap ferrules fitted to the tubes, all of which was completed on July 22, when she started for her station; but an auxiliary feed pipe burst, detaining her until the evening of the 24th, when she left, rejoining her fleet at Berehaven evening of 25th. The *Sappho* developed an old crack in her boilers while being tried in the Downs on the 13th, but it being slight the repairs were made by her engineer's force, and she left for her station after a few hours detention.

On July 17, the *Nelson's* steam steering engine broke down, necessitating using the hand wheel for awhile.

On July 18, the *Speedwell* developed leaky boilers, and was sent into Devenport dockyard, where repairs were commenced at once and completed by afternoon of the 20th, when she left to rejoin her fleet.

The GALATEA'S steam steering engine broke down on the 19th, and she had to drop out of the fleet to repair it. On the 25th, she developed faults in her eccentrics, which were repaired by night of 26th. She was again in trouble with 1 engine disabled on the early morning of August 4, but managed to keep up with the fleet and go into action soon afterwards.

The PEARL during the "preliminary exercises" developed leaky joints of the main and auxiliary steam pipes, which continued to give trouble until the action of August 4, when their condition was so bad that she barely managed to keep with the fleet until the action was over.

The HERO'S engines gave trouble several times, and necessitated her dropping out of station temporarily.

On July 19, when getting under way at Falmouth, No. **85** collided with the pier through a mistake in the engine room and knocked a hole in her bow, flooding the forward compartment. She was ordered to Devonport for repairs, proceeding under her own steam. Repairs were completed on the 21st, and preparations were made to leave the same night, but the patch on her bow failing to stand the water-pressure test she was further detained until 4 p. m. of the 22d, when she got away. At 10:30 p. m. of that day, while attempting to cross the bow of a schooner off the west coast of Cornwall, she was struck on the quarter, carrying away the steering gear and other fixtures and knocking a hole in her side above the water line. The steering gear was temporarily repaired in 2 hours, and she was able to return to Devonport, arriving at 11 a. m., 23d. A survey estimating 10 days for repairs. No. **86**, a sister boat, was ordered into commission with the same crew and equipment on the 25th. During the afternoon of that day she went outside for engine trials, which were unsatisfactory, joints leaking, valves

not working well, and rudder badly bent, necessitating return to the dockyard. Repairs to engine and boilers were completed by the evening of the 26th, and the rudder was replaced by that of No. **85**. She left for her station the same night; but on the following day, on account of leaky tubes, put into Pembroke for repairs, and there was captured on the 28th by a hostile gunboat and never joined the BLUE side, but was later commissioned by the *Red* side and used by them.

On the 21st, the *Salamander* had her outboard delivery choked, requiring a diver to clear it. She was not able to keep with the fleet on the 30th, owing to badly leaking condenser tubes, and was ordered to Devonport for repairs; the weakness had developed on the 27th and become gradually worse. Day and night work by the dockyard hands enabled her to get away to rejoin her fleet by night of August 2.

The steam steerer of the *Gleaner* broke down the night of the 21st, and she had to drop out of the fleet to repair, as it was with difficulty that she could keep station using the hand wheel.

The *Sheldrake* developed leaks in her steam pipes, and on the 25th, she was sent from Lamlash to Greenock for repairs, which were completed on the 26th, and she rejoined her fleet. On the 31st, she was ordered to Devonport with leaky condenser tubes and a damaged crank shaft which had to be taken out. Repairs were completed by night of August 2, but she did not rejoin her fleet in time for the action of August 4.

The *Narcissus* broke down completely early on the 28th, and went to Pembroke dockyard with a bent piston rod and a damaged cylinder. Repairs were at once commenced, but were not completed until the evening of August 2, when she was given a trial of her engines, which proved unsatisfactory, and further repairs detained her until the afternoon of the 3d.

The *Mersey's* capstan engine broke down while getting under way at Lamlash on the 27th, and hand gear had to be used, causing some delay.

The steam steering engine of the *Terpsichore* failed on the 30th, but was repaired by morning of 31st.

The *Niger* got aground in Milford-Haven on the 31st, but got off the next tide with help from the *Narcissus*.

The *Aurora* had to drop out of her fleet the night of August 3, with one engine disabled, but rejoined after a delay of 2 hours.

On the night of August 5, the *Gossamer* was discovered to be leaking badly, and was ordered to Plymouth, where she arrived early on the morning of the 6th, with much water in her.

On August 7, a steam cutter of the *Narcissus* collapsed the crown of her furnace, scalding 5 men, 3 of them seriously.

Of the torpedo boats a number burned out their grate bars, and had to replace them from their depot ships. On the night of the opening

N. LAT. 55° NORTH LIMIT OF MANOEUVRE-AREA.
W. LONG. 13° WEST LIMIT OF MANOEUVRE-AREA
W. LONG. 3° EAST LIMIT OF MANOEUVRE-AREA
FIELD OF
BRITISH
NAVAL MANŒUVRES.
1893.
NAUTICAL MILES.
0 10 20 40 60 80 100
STATUTE MILES
0 10 20 40 60 80 100 120
PLACES OF ASSEMBLY.
N. LAT. 49° SOUTH LIMIT OF MANOEUVRE-AREA.
IRELAND.
BRITAIN
ATLANTIC OCEAN.
IRISH SEA
ENGLISH CHANNEL.
BRISTOL CHANNEL
ST GEORGE'S CHANNEL.
NORTH CHANNEL
F. OF CLYDE
GLASGOW
EDINBURGH
LAMLASH
PORT PATRICK.
LARNE
SOLWAY F.
ISLE OF MAN
MORECAMBE B.
LIVERPOOL
ANGLESEY
CALF OF MAN.
CARLINGFORD
STRANGFORD
BELFAST
DUNDALK
DUBLIN
HOWTH
KINGSTOWN
WICKLOW
WEXFORD
WATERFORD
QUEENSTOWN
CORK
O. CLEAR
BEREHAVEN
VALENTIA
FORBIDDEN BELT.
52°10' N. LAT.
52° N. LAT.
SHANNON
LIMERICK
ARAN Is.
GALWAY.
BLACKSOD B.
ERRIS Hd
DONEGAL B.
SLIGO
TORY I.
MALIN Hd
LONDONDERRY.
CARDIGAN BAY.
MILFORD HAVEN
CARDIFF
BRISTOL
SEVERN
PORTSMOUTH
BILL OF PORTLAND
TORBAY
PLYMOUTH
EDDYSTONE.
FALMOUTH
LIZARD Hd
LANDS END
SICILLY Is.

of hostilities (July 27), one of the Larne boats had to return and go under repairs for 2 days, owing to the breakdown of her condenser. No. **81** damaged her stern on the 3d, and had to tie up for a few days at Kingstown coal wharf. Entering Portsmouth on the night of the 11th, she collided with a yacht lying at a bouy with slight damage to herself but considerable to the yacht. The series of disasters to Nos. **85** and **86** previous to hostilities have been before related.

The *Superb* had a fire below on July 23, caused by the ignition of clothing drying on steam pipes, and the forward magazines were flooded before the source of the smoke was discovered.

The *Vulcan* developed defects which required a lengthened stay at the dockyard she had just left. The *Jason's* steering gear gave much trouble. The *Jaseur* had shown the same defects and the *Skipjack* developed similar troubles.

The FORTH lost a man overboard while being chased on the afternoon of August 1, and the same ship while on her way to Plymouth, on August 12, was caught in a thick fog, and under steerage way, reported at 3 knots, struck a merchant steamer of 2,000 tons in the waist, cutting a hole from the bilge to the rail of the steamer 25 feet long by 24 inches wide, displacing the boilers and wrecking the fire room. The steamer's engine-room and fire-room bulkheads saved her from sinking, and the FORTH towed her into Plymouth, where it was found that her own forward store-room compartments were full of water, the ram bent to port at an angle of 45 degrees and several holes through the port-bow plating and a couple in the starboard bow, two of the holes being below the protective deck. The speed was so very low that this amount of damage appears rather remarkable.

FRENCH NAVAL MANŒUVRES.

By Lieut. P. V. LANSDALE, U. S. Navy,

Staff Intelligence Officer.

MEDITERRANEAN.

The manœuvres, which were of an unusually interesting and instructive character, were carried out simultaneously in the English Channel and the Mediterranean.

The ships taking part in the latter were the 3 divisions of the Active Squadron and 2 divisions of the Squadron of Reserve, as follows:

ACTIVE SQUADRON.

Ships.	Coefficient of military power.	Displacement.	Speed.	Main battery.
Battle ships:		*Tons.*	*Knots.*	
Formidable (flag)	36	11,440	16.2	Three 37cm (14″.6); four 16cm (6″.3) B. L. R., and ten 14cm (5″.5) R. F.
Courbet	35	9,650	15.4	Four 32cm (12″.6); four 27cm (10″.6) B. L. R. and ten 14cm (5″.5) R. F.
Redoubtable	30	8,850	14.8	Eight 27cm (10″.6); two 24cm (9″.5); six 14cm (5″.5) B. L. R.
Hoche (flag)	36	10,650	16.2	Two 34cm (13″.4); two 27cm (10″.6) B. L. R., and eighteen 14cm (5″.5) R. F.
Neptune	36	10,630	16.5	Four 34cm (13″.4); sixteen 14cm (5″.5) R. F.
Duperré	34	10,480	14.3	Four 34cm (13″.4); one 16cm (6″.3) B. L. R., and fourteen 10cm (3″.9) R. F.
Marceau	36	10,580	16.5	Four 34cm (13″.4) B. L. R., and seventeen 14cm (5″.5) R. F.
Baudin	36	11,380	15.2	Three 37cm (14″.6) B. L. R; four 16cm (6″.3), and eight 14cm (5″.5) R. F.
Dévastation (flag)	35	9,640	15.1	Four 32cm (12″.6); four 27cm (10″.6); six 14cm (5″.5) B. L. R.
Protected cruisers:				
Cécille	21	5,760	19.2	Eight 16cm (6″.3) B. L. R., and ten 14cm (5″.5) R. F.
Alger	16	4,100	19.6	Four 16cm (6″.3) and six 14cm (5″.5) R. F.
Davout	13	3,000	20.7	Two 14cm (5″.5) R. F., and four 16cm (6″.3) B. L. R.
Cosmao	8	1,880	19.5	Six 10cm (3″.9) R. F.
Troude	8	1,880	20.9	Six 14cm (5″.5) R. F.
Lalande	8	1.880	19.5	Four 14cm (5″.5) and two 10cm (3″.9) R. F.
Torpedo vessels:				
Wattignies	7	1,310	18.6	Six 10cm (3″.9) R. F.
Faucon	7	1,240	17	Five 10cm (3″.9) R. F.
Vautour	7	3,390	17	Five 10cm (3″.9) R. F.
Léger	3	430	18.8	One 65mm, and three 47mm R. F.
Lévrier	3	430	18.5	Four 47mm R. F.
Bombe	2	490	18.5	Four 47mm R. F.
Torpedo boats:				
Audacieux	.....	103	20.3	Two torpedo tubes.
Ouragan	.....	148	20	Four torpedo tubes.
Téméraire	.....	148	20.5	Do.
Coureur	.....	120	23.8	Two torpedo tubes.
Kabyle	.....	106	21.5	Do.
Dragon	.....	119	25.5	Do.

RESERVE SQUADRON.

Ships.	Coefficient of military power.	Displacement.	Speed.	Main battery.
Battle ships:		*Tons.*	*Knots.*	
Richelieu (flag)	29	8,760	13.2	Six 27cm (10″.6); five 24cm (9″.5); seven 14cm (5″.5).
Colbert	28	8,450	14.4	Eight 27cm (10″.6); two 24cm (9″.5); six 14cm (5″.5).
Coast defense vessels:				
Caïman	25	7,200	15	Two 42cm (16″.5) B. L. R.; four 10cm (3″.9) R. F.
Indomptable	25	7,200	14.8	Two 42cm (16″.5) B. L. R.; four 10cm (3″.9) R. F.
Terrible	25	7,700	14.5	Two 42cm (16″.5) B. L. R.; four 10cm (3″.9) R. F.
Protected cruisers:				
Tage	21	7,300	19.1	Six 16cm (6″.3); ten 14cm (5″.5); two 65mm R. F.
Forbin	8	1,800	20.6	Four 14cm (5″.5) R. F.
Milan	4	1,500	17	Five 10cm (3″.9) R. F.
Condor	7	1,200	17.7	Five 10cm (3″.9) R. F.
Torpedo vessels:				
Flèche	2	400	18	Four 47mm R. F.
Dague	2	400	18	Four 47mm R. F.
Dragonne	2	400	18	Four 47mm R. F.
Torpedo boats:				
Orage	None assigned.	106	21.5	Two torpedo tubes.
Éclair	...do	106	21.5	Do.
Aventurier	...do	148	20.5	Four torpedo tubes.
Agile	...do	103	20.4	Two torpedo tubes.

Armed vessels at Toulon: *Gironde*, torpedo transport; *Fusée* and *Mitraille*, armored gun vessels. Torpedo boats: *Doudard de la Grée*, and Nos. *27*, *94*, *95*, *96*, *100*, *103*, *104*, *123*, *124*, *151*, *167*, *172*, *173*, and *180*. At Corsica there were 6 torpedo boats; on the coast of Algeria, 4, and at Bon, 5. Seventy-six vessels took part in all. The original scheme of operations underwent considerable modification, but it is only necessary to describe them here as they were actually carried out. The period from July 1, to 10, was occupied in a preliminary cruise, which was taken up in steam tactics, signaling at long distances, scouting, and torpedo-boat exercises.

From the 10th, to the 16th, of July the ships remained at Toulon, then followed the regular manœuvres. The ships from the Squadron of Reserve, which took part, will be termed Squadron "A." Its base of supplies is at Hyères, near Toulon, and it is in possession of the neighboring coast of France, having the support of its torpedo boats and semaphore stations. It is to attack the territory defended by Squadron "B." The latter, made up of vessels from the Active Squadron, with headquarters at Ajaccio, Corsica, was supposed to be defending that island, besides a sector of the coast of Africa, included between Bougie on the west and Cape Bon on the east. The semaphore and torpedo-boat stations within this district were put in readiness to assist in the defense.

SQUADRON "A" (ATTACKING).

[Rear-Admiral Proubet, commanding.]

Ships.	Coefficient of military power.
Battle ship:	
Colbert (flag)	28
Coast-defense vessels:	
Terrible	25
Indomptable	25
Protected cruisers:	
Tage	21
Forbin	8
Condor	7
Milan	4
Torpedo vessels:	
Flèche	2
Dague	2

SQUADRON "B" (DEFENDING).

[Rear-Admiral Gadaud, commanding.]

Battle ship:	
DÉVASTATION (flag)	35
Protected cruisers:	
CÉCILLE	21
COSMAO	8
ALGER	16
LALANDE	8
FAUCON	7
DAVOUST	13
VAUTOUR	7
TROUDE	8
Torpedo vessels:	
LÉGER	3
LÉVRIER	3
BOMBE	2

[Rear-Admiral Lebourgeois.]

Battle ships:	
HOCHE (flag)	36
NEPTUNE	36
MARCEAU	36

Vice-Admiral Vignes, whose flag was hoisted on board of the "Formidable," was the director of the manœuvres and chief umpire. He was aided by Vice-Admiral de Boissoudy, who was an umpire.

The director of the manœuvres laid down an elaborate set of rules. The principle of reducing the fighting value of ships coming out of action seems to have promised a nearer approach to the realities of war than was the case with the rules governing other manœuvres. The

same may be said of a rule that ships captured or destroyed could take no further part in the operations. In every case the superiority was to belong to the force possessing the greatest number of points, and the ships were always to be considered as in action when they were within 3,280 yards of one another. The issue of the engagement was to be determined thus:

Every single ship having had an action with a superior adversary was to be considered as captured or destroyed; but the adversary, herself, was to lose by the victory her own fighting value to the extent of one-third of the points represented by her prize. In the case of several ships being concerned in such a success, this loss of points was to be borne by the strongest of them, and in all subsequent engagements every ship so reduced was to hoist a signal giving her actual fighting value at the time. When groups of vessels were opposed, the weakest was to be destroyed if the totals of the points representing the respective forces of the two adversaries were in the relation of more than 3 to 2; if less than this proportion, then the weaker side would lose its strongest ship and the superior its least considerable. (This rule was not to apply to an engagement between the respective divisions of Rear-Admirals Le Bourgeois and Prouhet.) Another rule was to the effect that every battle ship, cruiser, or torpedo vessel, having been torpedoed 4 times from a distance of less than 437 yards, without having perceived or fired upon her assailant, was to be considered as destroyed. The result of an action could only be decisive if the ships, by day, had been within at least 3,280 yards for 20 minutes, or if the weaker had passed within less than 1,090 yards, and by night if the inferior vessels had been under the electric light during the same time. A torpedo boat would be destroyed by being under fire for 90 seconds at less than 2,180 yards by day, or by being sighted for 1 minute by the search light at night. After an engagement the opposing groups of vessels were to steam severally 30 miles in diametrically opposite directions, the weaker side choosing the course. In the series of operations at simple action, that is, in the second phase of the manœuvres, certain torpedo boats, playing the part of torpedo vessels, were given equivalent points to the BOMBE. Each would be considered inferior to 4 torpedo boats; she would endeavor to escape, and would be considered destroyed if under their fire for 5 minutes at less than 1,090 yards.

It may also be noted that the formation of column of vessels was adopted as the usual one in cruising, not as necessarily the best, but "in order to secure those guarantees, which, as prudence dictates, should rule evolutions during time of peace, wherein it is necessary to avoid above all, those risks of collision which should or might be the principal object in time of war."

Rear-Admiral Gadaud's division of Squadron "B" was directed to watch the enemy at Hyères Islands, to keep touch with him, and at the same time to transmit to Ajaccio such information as would enable

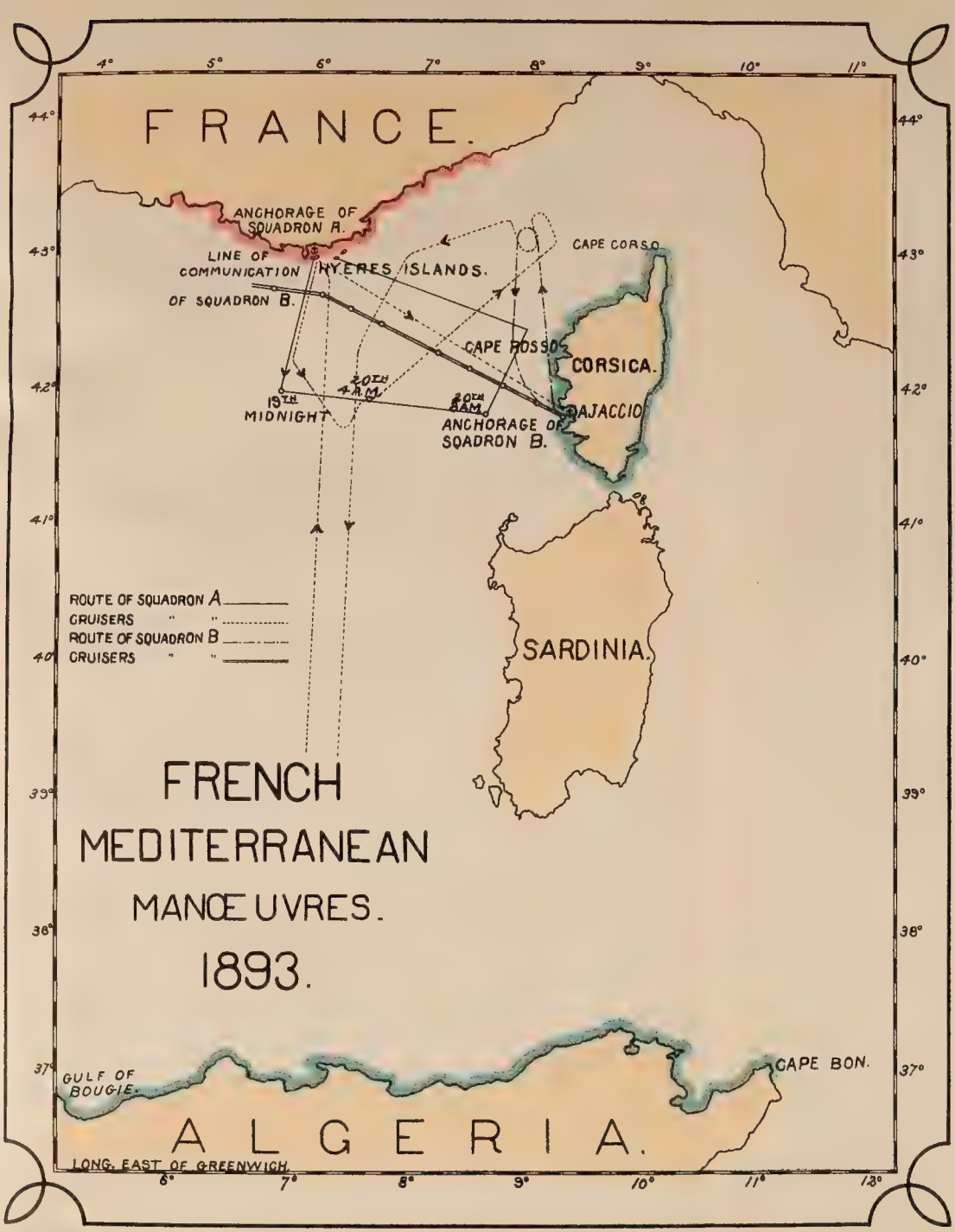
Rear-Admiral Lebourgeois, with his powerful battleships, to fall upon the invaders. By the rules, if the attacking force could remain undisturbed for 6 hours within 8,700 yards of a place, the object of the attack was attained.

Squadron "*A*" came to an anchor at Hyères on July 17, "B" arriving the same day at Ajaccio. Hostilities commenced at noon of the 19th. Admiral Prouhet ("*A*"), for some reason, did not attempt to steal out under cover of darkness, through one of the three channels available, but made the signal to get under way during daylight, at 6 p. m., July 19. The cruisers from the defending squadron, headed by the CÉCILLE and ALGER, had already formed an extended column from Ajaccio, distant 130 miles. Admiral Gadaud had provided for the transmission of the news of the enemy's movements by means of long-distance signals passed from ship to ship, as far as Ajaccio. He arranged to keep in touch with the enemy, by instructing these ships to make a wheel as the opposing squadron changed its position, the vessels farthest west keeping them in sight, while the others move in parallel arcs.

When Squadron "*A*" quit Hyères it was followed by two or three of the enemy's cruisers. These, being pursued by the *Tage*, *Forbin*, *Milan* and *Condor*, lost sight of the main body of "*A*" by 10 p. m. This resulted in considerable confusion among Admiral Gadaud's scouts, which culminated in one of them signaling that Squadron "*A*" was threatening an attack on Cape Corso. The DAVOUST, however, soon made known to Ajaccio the true state of affairs. Early in the morning of the 20th the ALGER was captured by the *Tage*, after a 4 hours' chase, and returned to her anchorage. The latter cruiser, together with the *Forbin*, *Condor*, and *Flèche*, continued on to the northeast, where they soon discovered Admiral Lebourgeois's division of Squadron "B" cruising near Cape Corso under the erroneous impression that that point was the object of Squadron "*A's*" attack.

In the meantime Squadron "*A*" stood south until midnight, and then headed east with the evident intention of attacking the coast of Corsica near Ajaccio. But as stated above, its approach was soon made known to the defenders, and Admiral Lebourgeois was warned in time to meet Squadron "*A's*" attack. The Hyères force was thus defeated.

Admiral Prouhet's original plan of attack was to make a descent upon the African coast, employing his cruisers to keep the enemy's scouts at such a distance from his command that they should be in ignorance of his whereabouts. With this end in view he appointed a rendezvous for his cruisers at a point south of Sardinia. But after they had steamed far beyond signaling distance he determined upon the attack upon Ajaccio. This, as we have seen, was abortive. But the *Tage*, together with the *Forbin*, *Condor*, and *Flèche*, repaired to the place of meeting on the African coast, and having searched with their torpedo boats for the rest of the squadron without result, sailed for Hyères. Here, to their great amazement, they found Squadron "B."


FRANCE.
ANCHORAGE OF SQUADRON A.
LINE OF COMMUNICATION OF SQUADRON B.
HYERES ISLANDS.
CAPE CORSO.
CAPE ROSSO.
CORSICA.
AJACCIO
19TH MIDNIGHT
20TH 4 A.M.
20TH 8 A.M.
ANCHORAGE OF SQADRON B.
SARDINIA.
ROUTE OF SQUADRON A
CRUISERS " "
ROUTE OF SQUADRON B
CRUISERS " "
FRENCH MEDITERRANEAN MANŒUVRES. 1893.
GULF OF BOUGIE.
CAPE BON.
ALGERIA.
LONG. EAST OF GREENWICH.
4° 5° 6° 7° 8° 9° 10° 11°
44° 43° 42° 41° 40° 39° 38° 37°
6° 7° 8° 9° 10° 11° 12°

Being ignorant of the fact that the operations in which they were engaged had been concluded by the defeat of the force to which they belonged, the commanding officer concluded to repair to Ajaccio. Here, he at last found Admiral Prouhet, who was just starting another phase of the manœuvres.

The operations which concluded this period consisted of a pitched battle between the Squadron of Reserve and the Active Squadron at sea on July 25. The CÈCILLE, on her way to Hyères after this action, ran down the British cargo boat *Fernando*, making a large hole in her starboard quarter, through which water entered and put out the fires. She sank in half an hour, but all the crew were saved. The CÈCILLE smashed her bowsprit, telescoped her bows, and twisted her ram to port, besides losing an anchor.

Part of the fleet now sailed for the Corsican coast, where some extremely interesting experiments were conducted. The French Mediterranean ships had not previously had opportunities of firing at elevated objects with heavy guns; and as many of the strongest modern littoral forts are situated upon lofty rocks, it was deemed desirable that the vessels should be given some practical experience of the difficulties of hitting such targets. The place chosen for the operation was the Gulf of Porto, on the west coast of Corsica. The target was the summit of Cape Rosso, which forms the southern limit of the gulf. The *Cosmao* took up a position from which the results could be observed. The vessels detailed for the firing were the *Formidable*, *Courbet*, *Redoutable*, *Hoche*, *Admiral Duperré*, and the *Dévastation*, and the practice began at 9 a. m. on August 8. The range was 8,750 yards, and the speed of the ships 10 knots. In the first round only the *Formidable*, with her 16-c. m. (6.3-inch) and the *Hoche*, and *Courbet*, with their 14-c. m. (5.5-inch) guns, took part. Subsequently all 6 battleships, steaming at 8 knots, fired at a range of 3,800 yards, using all their guns. In each of these trials the ships steamed ahead on a prescribed course. Finally the *Formidable*, *Hoche*, and *Courbet*, steaming at 10 knots in the arc of a circle, of which the target, at a distance of 8,750 yards, was the center, fired once more. The results are said to have been only moderately satisfactory. Before the fleet again anchored off Toulon, some subsidiary operations were carried out between the battle ship *Neptune*, escorted by the torpedo vessel *Bombe*, and torpedo boats *Kabyle* and *Ouragan*, and a number of torpedo boats, supported by the torpedo vessels *Lèger* and *Lévrier*.

After the ships were inspected the manœuvres were brought to a close.

CHANNEL MANŒUVRES.

The French manœuvres in the English Channel were, upon the whole, of a more exciting nature, though conducted on a smaller scale, than those in the Mediterranean. The general idea was as follows: An enemy, Squadron "*A*," supposed to be in the North Sea, 150 miles from

the Straits of Dover, endeavors to enter the channel and attack the coast of France. The defense, Squadron "B," anchored at Cherbourg, is warned by its cruisers of the approach of the enemy, whom it thereupon seeks to meet and defeat. During this search Squadron "B" will remain in constant communication with the coast, so as to be notified as quickly as possible of a pronounced attack upon any point within the first maritime district. The semaphore stations and batteries on shore lend their aid in the defense. The enemy will try to pass through the straits without being seen, and afterwards fall upon the French coast, avoiding any decisive action.

The coefficient value of the attacking squadron was 172; that of the defending was 217.

SQUADRON A (ATTACKING).

[Rear-Admiral Barrera, commanding.]

	Displacement.	Speed.	Main battery.
Armored cruiser:	*Tons.*	*Knots.*	
Victorieuse	4,700	12.8	Six 24cm (9".5), one 19cm (7".5), and six 14cm (5".5) B. L. R.
Coast-defense vessels:			
Furieux	6,000	13.8	Two 34cm (13".4) B. L. R.
Tonnerre	5,530	14	Two 27cm (10".6) and four 12cm (4".7) B. L. R.
Cruisers:			
Isly	4,160	19	Four 16cm (6".3) B. L. R. and six 14cm (5".5) R. F.
Epervier	1,240	17.2	Five 10cm (3".9) R. F.

In addition to the above, torpedo boats *Turco*, *Grenadier*, and *Grondeur*.

SQUADRON B (DEFENDING).

[Vice-Admiral Lefèvre, commanding.]

Battle ship:			
SUFFREN	7,780	14.3	Four 27cm (10".6), four 24cm (9".5), and seven 14cm (5".5) B. L. R.
Coast-defense vessels:			
REQUIN	7,200	15	Two 42cm (16".5) B. L. R.
FULMINANT	5,650	13.8	Two 27cm (10".6) B. L. R.
Cruisers:			
SURCOUF	1,850	19.5	Four 16cm (6".3) and two 14cm (5".5) R. F.
ECLAIREUR	1,658	15	Eight 14cm (5".5) B. L. R.

In addition to the above were the torpedo boats LANCE, SALVE, VÉLOCE, DÉFI, and LANCIER and all the mobilized defenses of the English Channel ports in the first naval arrondissement, which included 7 torpedo boats at Dunkirk; at Havre, 7; at Cherbourg, the armored coast-defense vessels, TONNANT and VENGEUR, the gun vessel FLAMME, armored cruisers TURENNE and LA GALISSONNIÈRE, first-class torpedo boat ZOUAVE, and 6 small torpedo boats; at Brest, the armored coast-defense vessel TEMPÊTE and 6 torpedo boats; at Toulon, the armored

gun vessels ACHÉRON, FUSÉE, and MITRAILLE, the transport GIRONDE, and 8 torpedo boats. At Lorient and at Rochefort were 4 torpedo boats.

At Brest the *Dupuy-de-Lôme* and *Isly* were detailed to receive the reservists, and at Toulon the *Magenta*.

Hostilities began at midnight of July 20. From that time fleet A ceased to communicate with the semaphores of the French coast. Being 150 miles from the straits it can not undertake to force that passage until a period of time has elapsed which would be necessary to traverse that distance at the best speed of the slowest vessel. On the first day of hostilities the SURCOUF, accompanied by 5 torpedo boats, cruised in the Straits of Dover, but saw nothing of Squadron "*A*." Early in the morning of the 22d, the *Isly* in the lead, Admiral Barrera passed the straits unperceived by the scouts of Squadron "B." Later it was learned from the North Goodwin light-ship that 3 French armor clads, 2 cruisers, and 3 torpedo boats had been sighted. About this time the SURCOUF, out from Boulogne, was chased by the *Epervier* and *Isly* to within a few miles of the English coast, but her superior speed saved her. The presence of the enemy was soon made known at Cherbourg, and Admiral Lefèvre got under way with his command. He was unfortunately too far away from Boulogne to prevent that town from being bombarded, and this the enemy accomplished. The FLAMME and 3 torpedo boats were located there during the bombardment. At 6 o'clock on the evening of the 22d, Squadron "B" was between Havre and the Isle of Wight, steaming in line; here the SURCOUF rejoined and reported that her port engine had broken down. At this time the *Isly* was observed chasing 2 of the "B" torpedo boats, which pursuit she did not abandon until within 6 miles of the squadron to which they belonged.

Having spent the night in cruising in column between the mouth of the Seine and Antifer, Squadron "B" stood north, the SURCOUF and torpedo vessels in advance. The SURCOUF, with only 1 engine, steamed 14 knots and actually drew ahead of her squadron, which under pressure began to tail away and spread out. At noon the squadrons were not more than 10 miles apart, "*A*" being in full flight, the *Victorieuse* even making sail. A torpedo cruiser from "B", which strayed too far away from its squadron, was captured by the *Isly*, which ship was making 18 knots with ease, and hovering around the main body. By this time the SURCOUF'S starboard engine was on the point of giving out, and she fell a prey to the *Isly*. She was sent back to Cherbourg for repairs, convoyed by the ECLAIREUR, which ship had all along been steaming very badly. Squadron "B" was thus left without cruisers, so the commander in chief concluded to give up the pursuit, and signaled that the exercises were over. Squadron "*A*" sailed for Dunkirk, while "B" repaired to Cherbourg. There is little question that the former was beyond the power of Squadron "B" to catch, and that the

Isly would have put out of the race more of "B's" torpedo cruisers and boats. The success of this large cruiser, as against the small cruisers, and torpedo boats which had nominally superior speed, but which, it was shown they could not maintain in rough water, has made a great impression in French naval circles, and is likely to influence future construction.

The second part of the North Sea manœuvres began on July 31. The tug *Haleur*, at Brest, was selected to represent a battle ship, and accompanied by four torpedo boats went out under the command of Commandant Borgnis-Desbordes, and having chosen an anchorage, was discovered and attacked by 6 torpedo boats of the "Défense Mobile." On the night of August 3 the *Haleur* and her consorts made a return attack upon the roadstead, which was defended by 8 torpedo boats. The attack was declared to be successful, although the battle ship, by the rules, was destroyed. On the afternoon of August 3 the *Tonnerre*, *Epervier*, and *Salve* sailed from Cherbourg, and were followed by the torpedo boats, *Turco*, *Véloce*, *Lancier*, *Défi*, and *Grenadier*, which made a successful night attack upon the ships.

In all these operations torpedoes with collapsible heads were used.

The whole of the *Escadre du Nord* were then assembled at Brest and was inspected by Vice-Admiral Lefèvre.

ITALIAN NAVAL MANŒUVRES.

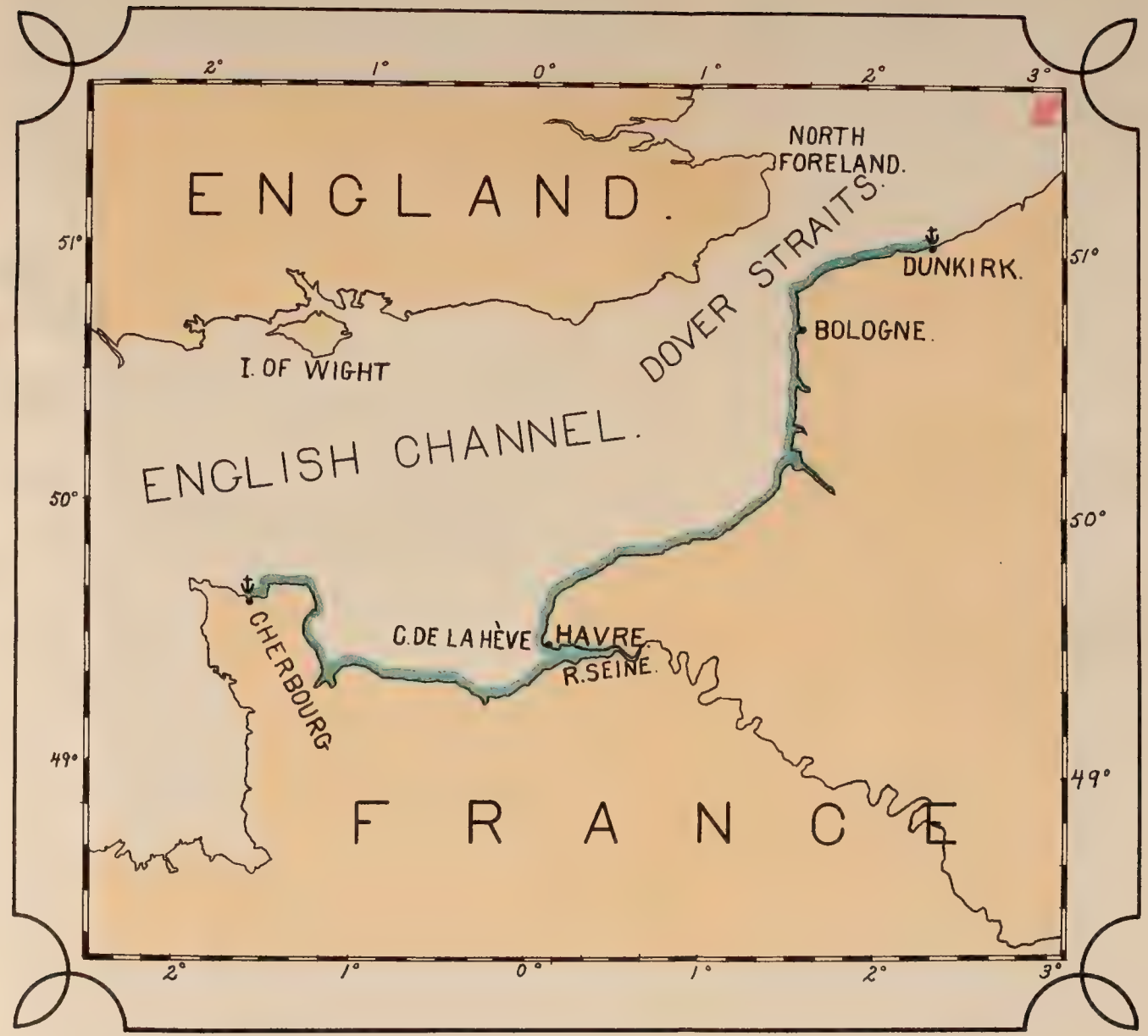
By Lieut. P. V. Lansdale, U. S. Navy,

Staff Intelligence Officer.

The following narrative is compiled from Italian, French, and English publications:

The Italian navy had undertaken no exercises of a strategical nature since 1888. It was therefore determined to employ a large number of ships and attempt the solution of certain definite problems previously arranged. It was late before the measure came up for deliberation, and not until the buget for the fiscal year of 1893 had been approved was it resolved to conduct the naval manœuvres on a larger scale than heretofore attempted. Vice-Admiral Bertelli was appointed the director of the manœuvres.

An order for the recall of the class of 1868, which had just been retired, was issued, and the length of time within which they were to report for duty was fixed at 10 days. It was determined to employ them by preference on shore duty, or to complete the complements of


ENGLAND.
NORTH FORELAND.
DOVER STRAITS.
DUNKIRK.
BOLOGNE.
I. OF WIGHT
ENGLISH CHANNEL.
CHERBOURG
C. DE LA HÈVE
HAVRE
R. SEINE.
FRANCE
2°
1°
0°
1°
2°
3°
51°
50°
49°

reserve or coast-defense ships. These men were retired in the beginning of 1893; some had been out of the service but one or two months, while a few were still on duty at the time the class was called out. It would have been preferable to have made the experiment with a class which had been out of the service for a longer time. Regarding this an Italian critic observes:

For this reason it would be rash to rely too confidently, in case of a general calling out of the reserve, upon the good results obtained from this attempt. To show, however, how successful the experiment was, the enlisted men of this class numbered 2,859; of these, 2,535 responded to the call, 104 were excused, 202 failed to appear from justifiable causes, 18 were missing without legitimate excuse, and more than three-quarters of those summoned presented themselves within the specified time. The remainder, who had already taken service on board of merchant vessels, reported subsequently.

In order to avoid overworking crews of inferior strength, some of the reserve were given duty on board the men-of-war taking part in the manœuvres, and their deportment on board was in every respect praiseworthy.

The details for the formation of the two squadrons appeared in the Journal of Ministerial Orders on July 1.

All of the ships were equipped by the 21st of the month, and included the following vessels:

PERMANENT SQUADRON (ATTACKING).

Commander in Chief, Vice-Admiral the Duke of Genoa, flying his flag on board the *Lepanto*.

First Division: *Lepanto*, *Lauria*, *Euridice*.

Second Division: *Italia*, *Doria*, *Iride*, under the command of Rear-Admiral Corsi.

Third Division: *Dandolo*, *Affondatori*, *Monzambano*, under the command of Rear-Admiral Gonzalez. Torpedo vessels: *Aquila* and *Sparviero*. Flotillas of seagoing torpedo boats as follows: First, Nos. *114*, *103*, *111*, *131*. Second, Nos. *141*, *146*, *125*, *126*. Third, Nos. *62*, *57*, *115*, *138*.

Additional ships: *Eridano*, coal transport; *Tevere*, tank vessel; *Volta*, hospital ship.

SQUADRON OF MANŒUVRES (DEFENDING).

Commander in Chief, Vice-Admiral Accini, flying his flag on board the RE UMBERTO.

First Division: RE UMBERTO, DUILIO, MINERVA.

Second Division: FIERAMOSCA, VESUVIO, ARETUSA, under the command of Rear-Admiral Marra.

Third Division: CASTELFIDARDO, STROMBOLI, URANIA, under the command of Rear-Admiral Puliga. Torpedo vessels: NIBBIO and AVOLTOIO. Flotillas of first-class torpedo boats as follows:

First. Nos. **59, 108, 94, 64.**
Second. Nos. **76, 77, 91, 139.**
Third. Nos. **137, 71, 73, 74.**

The tank vessel PAGANO was attached to this squadron. In addition to the above there were placed at the disposal of the commander in chief the reserve torpedo boats of Spezia and Maddalena besides those of the ports of Gaeta, Messina, and Taranto, which were sent to Gaeta, the Pontine Islands, and Naples. He was empowered to employ them within a radius of 100 miles from their base of operations. The following is a list of these torpedo boats: At Spezia—flotilla No. I, **90**, **93**, **96**; No. II, **109**, **86**, **105**, **88**; No. III, **127**, **87**, **117**, **140**. At Maddalena—No. I, **128**, **100**, **118**, **119**; No. II, **120**, **121**, **122**. At Gaeta—Nos. **99**, **129**, **95**. At Messina—Nos. **84**, **107**, and **135**. At Taranto, Nos. **64**, **112**, and **130**.

Vice-Admiral Bertelli hoisted his flag on board the "Trinacria" August 1. Several commissioned officers were assigned to each squadron to act as umpires. In charge of these on each side was a captain who was quartered on board of the senior flagship. Some other umpires were at the disposition of the chief umpire, to be assigned to duty as the occasion required. It was the duty of the umpires to collect and note the particulars of occurrences which they personally witnessed, or of which they had obtained trustworthy information. The commanders of a naval force, or of those ships to which umpires had been assigned, were required to notify him of their proposed movements. He was not to pronounce judgment upon the occurrences which took place, unless at the request of the authorities. He reported to the head umpire on his side and the latter, in turn, to the director of the manœuvres.

The field of operations was comprised within the following limits: The meridian of Ventimiglia on the west to its intersection with a line drawn from Cape Boco, passing 20 miles south of Sardinia. A line from Cape Boco to Trapani; from that port to Cape Campanella; then north along the coast to Ventimiglia.

The military and naval stations at Genoa, Spezia, and Maddalena were supposed to be manned and capable of resisting anything in the nature of a surprise, which was also assumed to be the case at Vado and Porto Conte, for which reason attacks were not to be made upon any of these five places, and they were not to be approached to within 3 miles. The fortifications in the neighborhood of Gaeta, San Stefano, and Argentario were considered to be armed and garrisoned, and at the first-named place the materials for a submarine obstruction were supposed to be at hand. The island of Elba was considered to be defended by the militia companies detailed for its defense. The Genoese coast from Cornigliano to Ventimiglia, and that on the western coast of Sardinia, between Castel Sardo and Cape Teulada was reserved for the *Permanent Squadron*. All the rest of the Italian coast comprised within the limits of the field of operations was reserved to the SQUADRON OF MANŒUVRES.

In addition to the semaphore stations situated on the coast above

mentioned, light temporary ones were established within the limits of the territory assigned to the SQUADRON OF MANŒUVRES. The regular telegraphic service continued in operation as in time of peace, and was used for the transmission of messages. The semaphore stations of Monte Argentario and Ponza were made central stations, which collected information from the surrounding posts and communicated it to the commander in chief. In the same manner they were employed to disseminate orders to ships which might be at any point along the coast.

Three themes to be developed successively during the manœuvres were indicated, with instructions to the commanders in chief of the two squadrons. They are summed up as follows:

Part to be taken by the *Permanent Squadron:* First theme. Starting from Vado to search for the SQUADRON OF MANŒUVRES, engage it in action, and obtain command of the sea. Should the adversary evade the encounter, endeavor to attract him by bombarding the undefended towns. After an interval of 5 or 6 days, to attack Naples, not omitting to break the line of communication between the islands and the mainland, and the destruction of the littoral railroads. Ships and torpedo boats were supposed to be stationed along the western Genoese coast sufficient for their protection.

Second theme: The squadron having obtained possession of the Gulf of Naples and of the islands, again approaches the adversary, who has in the meantime retired to a fortified harbor, where he is still sufficiently powerful to undertake sorties against the *Permanent Squadron.* After the lapse of 4 days the offensive operations against the enemy are increased, he is blockaded and attacked where he has taken refuge.

Third theme: Knowing the naval force of the enemy to be reduced to 1 battle ship, 3 cruisers of the second and third classes, and a few flotillas of torpedo boats, the squadron is to provide an escort for a fleet of 60 vessels, which is to proceed from the anchorage in the vicinity of Maddalena and enable them to effect a landing between Piombino and Fiumicino, or between Gaeta and Naples, at points out of range of the artillery of the permanent fortifications.

SQUADRON OF MANŒUVRES.

First theme: Being driven away from the harbors of Ferrajo, San Stefano, and Argentario, it is to oppose any offensive operations of the enemy against the Italian cities from Genoa to Naples, and all attempts to effect a landing on the unprotected parts of this coast, to prevent the destruction of the littoral railroad and the interruption of communication with the islands, keeping in mind the superior force of the attacking squadron. It is to avoid a general engagement, and to confine its aggressive operations for the most part to skirmishing and attempts at surprises by night. It is not to undertake operations against the enemy's coast, it being defended by ships and torpedo boats in addition to those engaged in the attack.

Second theme: After an unsuccessful encounter with the enemy the squadron has withdrawn to Gaeta, under the protection of its batteries. For greater security a line of obstructions in the form of an immense boom across the entrance of the harbor is built.

Third theme: The SQUADRON OF MANŒUVRES after other encounters with the enemy is reduced to 1 ship of the first class and 3 of the second and third classes, and some flotillas of torpedo boats. The military posts on the coast are still capable of affording protection, and the signal stations of the littoral remain intact as well as those of the smaller islands. These obtain definite information that the enemy, moving from the anchorage at the north of Sardinia, are preparing to effect a landing in force on the mainland. This the SQUADRON OF MANŒUVRES is to oppose in the most effective manner possible.

It will thus be seen that the character of the operations was to be especially strategic, but as the opposing forces were bound to come in contact sooner or later, certain rules were established to govern such encounters as follows: The meeting of one or more ships or torpedo boats of equal strength would cause the temporary disability of both; they must separate at once and return to the neighborhood of their chiefs. An encounter between ships of unequal strength would give the victory to the more powerful, provided he were able to overtake and keep up with the adversary for a certain prescribed length of time. A general engagement of the two forces would give to the *Permanent Squadron* the right to consider itself the victor if it could approach the adversary within a mile. The efficacy of torpedo boats and ships against one another was fixed according to certain standards, and the limits of time and distance to which they were subject established.

The extent and formation of a convoy was to be represented either at sea or at anchor by means of 4 ships, and in moving the convoy account was to be taken of the actual time required to move that number of vessels. Finally, the methods were indicated by which signals to railroads were to be understood, and interruptions of the submarine telegraph lines, bombardments of undefended cities, and the operations of disembarking accomplished.

As regards the signal stations, it was determined to test their efficiency in the use of search lights. The possibility of their becoming disabled by means of surprises was excluded, and they were understood to be defended by strong garrisons capable of preventing the landing of troops from ships no matter of what size.

To avoid the curtailing of the respective forces, and in order that there should be no ships inactive, it was decided that those which had become disabled by reason of an encounter with a more powerful adversary could again take part in the exercises after having rejoined their chief.

The coefficient of strength of each ship was determined by a scheme laid down by Captain Bettòlo, of the Italian Navy. Speed was regarded as an important factor. For greater simplicity the results were

reduced to whole numbers. First-class torpedo boats were credited with a uniform strength. The coefficients of certain ships were slightly added to or diminished, in order to reduce them to a few numbers easily remembered. Those of the *Affondatore* and CASTELFIDARDO, on the contrary, were considerably altered, their military value resulting from the method pursued for the others, being too small in proportion to that of the other ships. The strength of the respective sides was thus established.

	Type.	Coefficient of military strength	Displacement.	Speed.	Main battery
Attacking or permanent squadron:			*Tons.*	*Knot.*	
Lepanto	B. S.	10	14.860	18.4	Four 17″, eight 6″ B. L. R., and four 4″.72 R. F.
Lauria	B. S.	10	10.700	17.6	Four 17″, two 6″ B. L. R., and six 4″.72 R. F.
Italia	B. S.	10	15.400	17.6	Four 17″, eight 6″ B. L. R. and four 4″.72 R. F.
Doria	B. S.	10	10.200	17	Four 17″, two 6″ B. L. R., and four 4″.72 R. F.
Dandolo	B. S.	10	11.200	15.5	Four 17″.7 M. L. R. and four 4″.72 R. F.
Affondatore	B. S.	4	4.000	11.9	Two 8″ B. L. R. and six 4″.72 R. F.
Monzambano	T. V.	1	741	18	Battery of light R. F. G.
Iride	T. V.	1	856	20	One 4″.72 R. F.
Euridice	T. V.	1	856	19	One 4″.72 R. F.
		57			
Defending or squadron of manœuvres.					
RE UMBERTO	B. S.	14	13.300	18	Four 13″.5, eight 6″ B. L. R., and sixteen 4″.72 R. F.
DUILIO	B. S.	10	11.200	15	Four 17″.7 M. L. R. and four 4″.72 R. F.
FIERAMOSCA	Cr.	5	3.745	17.5	Two 10″ B. L. R. and six 6″ R. F
VESUVIO	Cr.	5	3.530	17.0	Two 10″ and six 6″ B. L. R.
CASTELFIDARDO	B. S.	4	4,259	12.0	Eight 5″.5 B. L. R. and six 4″.72 R. F.
STROMBOLI	Cr.	5	3,530	17.0	Two 10″ and six 6″ B. L. R.
ARETUSA	T. V.	1	846	20.0	One 4″.72 R. F.
MINERVA	T. V.	1	840	20.0	One 4″.72 R. F.
URANIA	T. V.	1	840	20.5	One 4″.72 R. F
		46			

The opening of hostilities was fixed for the 9th of August, at 6 a. m. Each commander in chief had issued special orders relating to the development of the proposed themes and fixed upon private signal codes. In addition to the tactical formations given in the Italian fleet drill book, each squadron had introduced others which demonstrated the views taken by the commanding admirals as to the manner in which the operations were to be further carried out.

There were five orders of sailing provided for the *Permanent Squadron*. The first included the 6 largest ships in a nucleus of hexagonal

form, with a distance of 1,310 yards between the leading and the rear vessel, and 550 yards across. Leading at a distance of 1,100 yards from the main body were 2 torpedo boats and 2 torpedo vessels, spread out over an extent of 8,740 yards. One cruiser followed at a distance of 5,470 yards astern. Torpedo boats were stationed alongside of the large ships.

The second formation placed all the ships in 2 columns, with the flagship leading, the distance between the column being 550 yards and the length 1,750 yards. The cruisers followed the battleships and the torpedo boats were disposed about the latter.

In the other orders of sailing the larger ships were grouped in equilateral triangles, or triangles of different kinds, torpedo boats following in line and others near the battle ships.

Of the abovenamed only the first had the character of a sailing formation, protected by lookouts at limited distances. The second was a sailing in close column, while the last three had the character of formation for battle. Hence it may be concluded that the intention of the Duke of Genoa was to keep his forces together, in order to make a united descent upon the enemy. Not fearing an attack, it was proposed to excite one by means of special operations, to be ordered as the necessity arose.

The formations of the SQUADRON OF MANŒUVRES were three in number. The first had a nucleus formed of the four battle ships UMBERTO, DUILIO, CASTELFIDARDO, and STROMBOLI, placed in a lozenge. The cruisers FIERAMOSCA and VESUVIO were 9,840 yards ahead, and the torpedo vessel ARETUSA 5,470 yards farther in advance; at a like distance astern was a flotilla of torpedo boats. The torpedo vessels URANIA and MINERVA and the 2 other flotillas of torpedo boats steamed off either beam about 3,280 yards from the guide. It thus had an extent of over 10½ miles in length and about 1 mile across. In the second order the 6 largest ships were about 5 miles distant from each other. Two and two-thirds miles in advance of the UMBERTO (battle ship), which was in the lead, came the MINERVA (torpedo vessel). Off the beams at a distance of 4,400 yards from the guide were the two other torpedo vessels and 4 torpedo boats. Eight of the latter followed some of the larger ships. This order of sailing had an extent of about 27 miles in length and about 4 in width.

The third order of sailing consisted of a single line with the exception of the URANIA (torpedo vessel) which followed the CASTELFIDARDO (battle ship.) The ships, accompanied by torpedo boats, were 1,100 yards apart.

The first two formations were intended for reconnoitering, and were formed of lines too weak to sustain an unexpected attack. Nor were they such as to permit of a rapid concentration to resist one. None of them were actually used during the manœuvres. The third order, though of smaller extent than the others, measured from end to end 3¼

miles. It is evident that Vice-Admiral Accini had excluded from his plans the idea of a general engagement with the adversary. For the developing of the first theme he had arranged to maintain the principal nucleus of his forces in a movable base between Ponza and Monte Argentario, to deploy lookouts in the direction of Vado and Savona, guard with torpedo boats the passage between Corsica and Elba, to reconnoiter with small detached squadrons from Maddalena, the waters to the south of Sardinia, and with the torpedo boat flotillas from Gaeta, Messina, and Taranto, watch the western coast of Cicily. He had laid down no exact plan of operations, holding himself in readiness to concentrate his forces at any point where it might seem possible to effect a surprise.

The Duke of Genoa on the other hand, drew up an itinerary of the movements of his ships for each day as follows:

First day: Soon after dark dispatch 2 cruisers and 2 torpedo vessels toward the island of Capraja and Gorgona to interrupt the telegraph communications, and toward S. Vincenzo, to destroy the railroad bridge. Later the squadron gets underway to damage the railroad at Moneglia, Levanto, and thereabouts.

Second day: The lookouts search for the enemy. The squadron simulates a bombardment of Leghorn, and withdraws at sunset to the west to descend later upon the eastern coast of Corsica, and then stands for Civitavecchia.

Third day: At daybreak a cruiser is dispatched to destroy the railroad bridge to the north of Follonica, the squadron proceeds to Civitavecchia, and simulates a bombardment of that town.

Fourth day: A division reconnoiters the harbor of Gaeta, and succeeds in drawing out the enemies ships, which it finds there. The squadron then departs.

Fifth day: Stands for Trapani by a devious route, where had been gathered the store ships. Sends ahead, under cover of darkness, scouts to reconnoiter the coast, and awaits their report.

Sixth day: In the morning takes possession of the harbor, and obtains a supply of coal and water, moves away at sunset, leaving the torpedo boats, but appointing a rendezvous with them for next day.

Seventh day: Heading for Naples.

Eighth day: Enter the gulf at day break, if the enemy is not encountered, simulates the bombardment of the city. Referring to the above an Italian critic writes:

The movements of the united force and of separate ships were minutely laid down; the duties of the scouts were particularized, but the principal aim of the squadron seems to have been forgotten, and in the itinerary of the fourth day bare mention is made that a division reconnoitering about Gaeta succeeds in drawing out the adversary, the search for whom and the attack which follows not appearing in the attitude of the object toward which all the preceding acts had been directed. Instead of this, the destruction of railroads and operations against undefended cities seems to have been the immediate object of the movements. It is quite true

that the adversary, provoked to active defense of his own coast by so many attacks made upon it, would perhaps have sought the encounter so eagerly desired by the *Permanent Squadron*. If this should not occur, the latter after some days would feel the need of coal, for which reason it must suspend operations and betake itself to some open port, where it would become much easier for the enemy to surprise him. Can this method of tracing out the entire plan of a campaign, even to the smallest details, be looked upon as instructive? It would seem not, if the examples of the most memorable battles are to serve as guides. As will be seen by the sequel, the *Permanent Squadron*, for the very reason that it held too rigidly to its itinerary, lost the most promising opportunity of dealing a death blow to the adversary, exposing itself meanwhile to receiving one in its turn.

On the morning of the 9th of August the respective forces were located as follows:

Permanent squadron (attacking).—All the ships were at Vado. The coal ship *Eridano* was at Savona. The torpedo boats were distributed among the ports already named, except Nos. *141* and *146*, which were to rejoin the squadron next day.

SQUADRON OF MANŒUVRES (DEFENDING).—At San Stefano and Ferrajo, except the *Vesuvio*, cruising in the Straits of Bonifacio, to the west of the island of Razzoli. At Cagliari were all of the Maddalena torpedo boats except 3; those belonging at Gaeta remained there, while those of Messina and Taranto, were deployed between Trapani, Favignana, and Maritimo.

August 9 at 9 p. m. the FIERAMOSCA (cruiser) and URANIA (torpedo vessel), accompanied by torpedo boat flotilla No. *2* and *3* additional torpedo boats, sailed from Ferrajo toward Maestro, hugging the coast, while the ARETUSA (torpedo vessel) and MINERVA (torpedo vessel) stood several miles farther out, steering toward Savona. The torpedo boats of the Spezia fleet, at Ferrajo, were occupied in cruising between Capraja, Elba, and Corsica. The remainder of the defending squadron were between Elba and Monte Argentario. Up to 3 p. m. none of the attacking squadron had left the anchorage except the two torpedo boats, *Aquila* and *Sparviero*, sent scouting. These discovered a lookout vessel of the enemy, the MINERVA (torpedo vessel), which news was communicated to the commander in chief. At 3 p. m. the squadron weighed anchor and steamed at a moderate speed to the south. It was sighted for a short time by the MINERVA (torpedo vessel). It then directed its course toward the eastern coast, deploying the *Euridice* (torpedo vessel) and the *Aquila* (torpedo boat) toward San Vincenzo (Tuesday) to destroy the railroad bridge, and the *Iride* (torpedo vessel) and *Sparviero* (torpedo boat) toward Capraja and Gorgona to break the telegraphic communications. During the afternoon the scouts from the defending squadron were near Genoa, but missed the adversary.

August 10: At daybreak the MINERVA (torpedo vessel) encountered the coal transport *Eridano*, coming out of Savona, on her way to a designated meeting place. She was captured, and contrary to the established conditions, she was obliged to follow, instead of being set at liberty again. At 5 a. m. the larger ships of the attacking squadron, the

Monzambano (torpedo vessel) and the torpedo boats, were off Levanto; the second and third divisions stood close to the shore, to simulate, by landing men and firing volleys of blank cartridges, the destruction of a tunnel and of 2 railroad bridges. The first division, with torpedo-boat flotillas, stood further out from land to frustrate any attempted surprise on the part of the enemy. Six or 7 miles to the southeast the FIERAMOSCA (cruiser), the URANIA (torpedo vessel), and the ARETUSA (torpedo vessel), and a torpedo-boat flotilla, were cruising, quite unaware of the proximity of the attacking squadron, on account of a thick fog which was hanging about the coast. At 6:30 a. m. the *Aquila* (torpedo boat), steaming towards Levanto, hove in sight, and drew attention to the presence of the squadron to which she belonged. About 9 a. m. the latter withdrew to the southwest, sending the *Aquila* (torpedo vessel) to Gorgona to communicate with the *Iride* (torpedo vessel) and *Euridice* (torpedo vessel). In the meantime Rear-Admiral Marra's division, after exchanging signals with the signal station at Palmaria, had stood to the southeast. The URANIA (torpedo vessel) was dispatched to locate the *Permanent Squadron* and observe its movements. In this she was successful, and this news was transmitted through the semaphore station at Porto Fino before sunset to the commander in chief of the defending squadron. The MINERVA, embarrassed by the slowness of the *Eridano*, sent her into Spezia. At 5 p. m., Rear-Admiral Marra, with the FIERAMOSCA (cruiser), ARETUSA (torpedo vessel), MINERVA (torpedo vessel), and a torpedo-boat flotilla, were off Antignano, and exchanged signals with the semaphore station at Montaccio.

Rear-Admiral Accini had received during the day news of the offensive operations conducted against the railroads, and calling together such ships as were in his neighborhood, stood to the north, notifying Rear-Admiral Marra of this move. The torpedo boats stationed between Corsica, Capraja, and Elba were sent to occupy the channel of Piombino. He soon discovered that the enemy's squadron had left, so returned to a meeting place 5 miles to the west of Monte Argentario. Rear-Admiral Marra, not knowing of the change of plans, remained with his command near Leghorn. Near midday torpedo boats Nos. **76** and **91** were surprised by the *Iride* (torpedo vessel) and disabled. The *Sparviero* (torpedo boat), finding that the attacking squadron was not off Leghorn, cruised about Capraja and Gorgona islands looking for it, and then stood for Cape Corso at nightfall to continue the search. Here she found herself in the midst of a numerous French fleet, from which she withdrew at full speed.

The attacking squadron, in the meantime, by a roundabout course, reached Cape Corso early in the evening. From thence it stood north, with lights extinguished, with the purpose of shaping a course for Civita Vecchia. All of the scouting vessels had rejoined except the *Spar-*

viero, which torpedo boat, after her encounter with the French fleet, had sought an anchorage at Capraja.

August 11: At 4 a. m. Vice-Admiral Accini, with the UMBERTO, (battle ship), DUILIO (battle ship), CASTELFIDARDO (battle ship), STROMBOLI (cruiser), and 16 torpedo boats, was a few miles off the island of Giglio awaiting news. The VESUVIO (cruiser), returned from a scouting voyage near the Straits of Bonifacio, while the rest of the ships were assembled to the north of the island of Elba. During the night the attacking squadron steered for Civita Vecchia, and after daylight passed in full view of the islands of Giglio and Giannutri. The news of its appearance, heading for Civita Vecchia, was signaled to the defending squadron, which, however, was delayed in getting under way. The Duke of Genoa's squadron, in the meanwhile, arrived off Civita Vecchia, and the third division opened fire on the town at noon. Lookout vessels were stationed in the offing and torpedo boats further in, while the other ships remained in readiness to resist any attack from the enemy. The latter was soon after seen approaching, so operations against the city were suspended, and signals were made for the squadron to assemble in a battle formation. The defending squadron left the waters of Giglio, formed in double column, but the UMBERTO (battle ship) set such a high speed that the ships tailed away and spread out. The latter was followed at a distance of more than 1,100 yards by the VESUVIO (cruiser), at 2,700 yards by the STROMBOLI (cruiser), and at 4,400 yards by the DUILIO (battle ship). The CASTELFIDARDO (battle ship) was 5 or 6 miles behind. The 16 torpedo boats were spread out between the UMBERTO (battle ship) and the 2 following ships. Neither squadron was regularly formed for battle when they were within a distance of 3 miles from each other. It may be remarked that the UMBERTO (battle ship) had a greater number of torpedo boats grouped about her than any of the opposing vessels had succeeded in collecting. When the UMBERTO (battle ship) was about 5,500 yards from the *Lepanto* (battle ship), which she was bearing down upon, she signaled to the rest of the squadron to put about and to the torpedo boats to attack. The latter continued to advance and opened fire. Owing to the extreme rapidity of the movement, it was most difficult for the umpire to judge of the extent of the injuries which might have resulted from the drawing together of the ships and torpedo boats. Except for this daring attack the *Permanent Squadron*, calculating upon its great superiority in military value, initiated the encounters. The director of the manœuvres now ordered the suspension of hostilities on account of the lateness of the hour, as it would hardly have been possible before sunset for the *Permanent Squadron* to have established a complete victory, in accordance with the rules prescribed.

It was perhaps the loss of all touch with the enemy which caused the very daring attack upon him to be made without the cooperation of the

division of Rear-Admiral Marra, which consisted of a torpedo vessel, two cruisers, and a torpedo-boat flotilla, which force could hardly have failed to have been of great service against the enemy.

An Italian writer observes:

Rear-Admiral Marra was at first instructed that the ships would rendezvous on the 11th in the waters of Giglio, but being advised by his chief on the 10th that the latter was proceeding toward Porto Fino, he determined to await him in the channel between Gorgona and Leghorn. When the commander in chief returned to the southward without informing his junior he omitted a precaution which, in actual warfare, it would have been well to observe. In any case, the division of light-ships should not have been kept waiting so long, nor should they have been confined in that small expanse of water. Had one of these cruisers been dispatched toward Capraja and Cape Corso on the evening of the 10th as a scout, she might have come up with the enemy's squadron, and, following for a time, have divined its intentions, instead of which the defenders, lacking all of this useful information, lost what would seem to have been an admirable opportunity for attempting a surprise by night with all their torpedo boats. The attacking squadron at the very beginning had an insufficient number and extent of lookout ships. The coal transport upon which they depended for their supply of coal was captured by a torpedo vessel of the enemy, but for several days they remained in ignorance of that fact. In actual war this occurrence might have caused the most serious inconvenience.

Upon the value of the encounter, in the absence of exact information from the umpires, it is almost impossible to give any opinion.

Rear-Admiral Marra's division remained to the north of Elba until the 12th, when it was dispatched to Ponza. In the afternoon, off Civita-Vecchia, the division encountered the *Iride*, having conveyed to that port a wounded man; she was headed off and disabled.

The attacking squadron steamed away to the southwest. Arrangements had been made to meet the coal transport *Eridano* at Trapani, when the probability arose that the enemy had gained knowledge of the plan; therefore it was determined to head for Cagliari instead, simulate the attack and capture of that port, and make use of the coal piles there.

The SQUADRON OF MANŒUVRES took up a position inside the Gulf of Naples, and at night anchored off the Villa Nazionale, rigging out torpedo nets. The STROMBOLI, (cruiser), and 2 torpedo vessels were stationed at the outer entrance.

For a period of more than 3 days the opposing forces had lost touch of each other.

The attacking squadron in the meantime stood for the Gulf of Naples at a speed of 10 knots. Thus the respective movements of the two squadrons was leading up to a meeting which was to be a great surprise to both.

August 15, the attacking force entered the gulf at 2 a. m. with all lights covered. The night was foggy and so dark that the attacking vessels, though grouped in close order, could hardly identify one another.

The MINERVA (torpedo vessel) at 12 p. m. signaled, "Suspicious ship

sighted;" the STROMBOLE (cruiser) repeated this signal, steaming for Naples. At 3 a. m. an answer was received from the UMBERTO (battle ship). At dawn the attacking squadron perceived ahead the defending ships forming for action, and at once assembled for the purpose of cutting off their escape, endeavoring at the same time to approach to within the distance required to establish their capture. Vice-Admiral Accini launched the whole of his 34 torpedo boats at the enemy, *en masse*, while the Duke of Genoa met them with 14 of his own.

It may well be said that the manner of the encounter was unexpected. Although the attacking squadron was able to surmise from the signals the presence of the adversary in the gulf, they were entirely ignorant until a few moments previously as to where they were or how formed. The SQUADRON OF MANŒUVRES, though having knowledge of the proximity of the others, were not aware that they were approaching or from what quarter the attack might be expected, since not one of their scouts had followed the enemy for even a short time.

The umpires had still greater difficulties here than at Civita Vecchia in obtaining clear and precise data, and the reports from the two sides not agreeing, it became difficult enough to expound the development of the action, which, moreover, was of short duration, and took place at daybreak close in to shore. These conditions imposed upon the commanding officers the closest attention for the safety of their ships, and it is easy to understand that the final phases of the action were not fully noted, and that many discrepancies appeared.

From the 20th to the 26th the 2 squadrons were engaged in coaling. The SQUADRON OF MANŒUVRES at Gaeta constructed an immense boom across the entrance to the anchorage, with mines and torpedoes at intervals, but leaving narrow passages at either end.

SECOND THEME OF THE MANŒUVRES.

In this the defending squadron was again matched with a superior adversary. Two flotillas of torpedo boats were transferred from the SQUADRON OF MANŒUVRES to the opposing force, so that the number now in possession of the two sides was nearly equal. Several torpedo boats were laid up for repairs.

It was, moreover, determined to hasten the operations in order that the King might be present at the attack of the torpedo boats on the ships and at the forcing of the blockades which the SQUADRON OF MANŒUVRES was to attempt.

On August 22, the Duke of Genoa received the order to conduct the attack on Gaeta with torpedo boats before midnight, and was informed that by that hour the SQUADRON OF MANŒUVRES would have come out, having forced the blockade.

Vice-Admiral Acceni was informed of the coming attack, and that he was to effect a passage to sea after midnight as secretely as posssible. Thus the second theme may be said to have been carried out in pur-

suance of a prearranged plan, amounting almost to a previous agreement between the opposing forces, so that little or nothing was left to the discretion and judgment of the respective commanders in chief.

The obstruction above referred to was for the most part real. A portion, however, was represented by fishing nets hung from cables upheld by floats. On Monte Conca a battery of six 2.95-inch guns had been erected to command the passage at the north end, while the opposite extremity was protected by 2 batteries armed with guns of 57 millimeters and 149 millimeters (5.87 inches).

Thus protected, the squadron lay with steam up and ready to put to sea at the decisive moment. At dusk the torpedo boats were sent outside the bar, and at 9 p. m. Vice-Admiral Accini was preparing to put to sea, when the approach of the enemy was signaled. The attacking torpedo boats appeared at first singly; afterward in greater numbers accompanied by cruisers. Some encounters ensued, and the shore batteries, as well as the guns of the UMBERTO, kept up a well-sustained fire against the torpedo boats. The southern passage was the principal point of attack. It is said that this night engagement presented a superb spectacle. Two torpedo boats of the attacking force, drawing cautiously near to those of the defense, managed to run in behind the barrier, not being recognized as belonging to the hostile fleet. One simulated an attack on the MINERVA, and the other on the UMBERTO. They then managed to rejoin their squadron unobserved, the ships of which advanced to receive and protect them.

The search lights were now suddenly turned off, and, taking advantage of the increased darkness caused by the setting of the moon, some of the ships steamed quietly out of the northern passage, the conflict between the torpedo boats being still carried on at the southern passage. Meanwhile the torpedo boats had succeeded in driving back the attacking ships a short distance, and the rest of the SQUADRON OF MANŒUVRES, with lights extinguished, made its escape through the southern passage to join the other ships at a rendezvous which had been agreed upon. At 2 o'clock in the morning both squadrons returned to Gaeta, where 27 battle-ships and cruisers and 50 first-class torpedo boats were assembled. The defenders had succeeded in their object.

THIRD THEME OF THE MANŒUVRES.

For the execution of the third theme the opposing forces were rearranged in the following manner:

Permanent squadron, representing the attacking force: *Lepanto* (flag), *Aquilla*, *Sparviero*. First Division, *Italia*, *Lauria*, *Iride*. Second Division, *Dandolo*, *Duelio*, *Euridice*. Third Division, *Fieromosca*, *Doria*, *Urania*. Besides these were 26 torpedo boats, divided into 7 flotillas.

Vice-Admiral Accini's command consisted of the UMBERTO, STROMBOLI, MINERVA, ARETUSA, AVOLTOIO, NIBBIO, and 22 torpedo boats; these were assembled at Spezia.

The director of the manœuvres informed the commanders in chief that hostilities would begin at 6 a. m., September 1.

September 1: The vessels of the SQUADRON OF MANŒUVRES took up positions as follows: The UMBERTO and a flotilla of torpedo-boats were formed between Giglio and Monte Cristo, while two torpedo boat flotillas were stationed between Monte Cristo and Alistro (Corsica). The ARETUSA, MINERVA, AVOLTOIO, and torpedo boat **65** S,[1] proceeded to cut across the course leading from Maddalena to Civita Vecchia, Porto d'Anzio, and Volturno, at a distance of about 30 miles from the Sardinian coast.

Between the hours of 12 and 2 p. m. the *Permanent Squadron* left the anchorage at Maddalena and assembled 6 miles to the northeast of Caprera in the formation of a square, having sides 4,900 yards in length. The *Castelfidardo*, *Affondatore*, *Vesuvio*, and *Monzambano* marked the corners. The *Lepanto* took the lead, followed by 2 flotillas of torpedo boats. The first division was on the port side, the second to starboard, while the third division brought up the rear, each with a flotilla of torpedo boats. The scouts sighted a cruiser and a torpedo boat at 7 a. m., but soon lost them. The *Euridice* and *Aquila*, on arriving at the cruising ground of the enemy's torpedo boats, forced them to retreat towards Corsica and Monte Cristo; they next proceeded to explore the waters north of Elba. The *Iride* steamed from Civita Vecchia to Maestro, thence towards Giannuti, to the northward of which island she sighted the UMBERTO, and reported the circumstance to the commander in chief.

At 1 p. m. the STROMBOLI and NIBBIO reached the Straits of Bonifacio, to the westward of the island of Razzoli, and being sighted from the signal station word was sent of their presence to the *Lepanto*. The STROMBOLI remained in these waters, while the NIBBIO passed through the straits in time to see the enemy's squadron taking up their cruising formation, and judging their course to be E. N. E., hastened back to the flagship to communicate the information. She was at once dispatched to go in pursuit of the *Permanent Squadron*, which was now steaming at a speed of only 6 knots. The latter stood for a meeting place previously arranged with their scouts, which was in a line between Civita Vecchia and the Straits of Bonifacia.

Each of the four ships at the corners carried a light at the masthead, the others being without lights of any kind.

September 2: At 3:30 a. m. the NIBBIO sighted some of the enemy's ships, and approaching within torpedo range of the *Castelfidardo*, simulated the firing of a torpedo against her. The NIBBIO was driven off at daybreak. The Duke of Genoa's command hove to in the early morning to receive the reports from the scouts. From them he learned that the enemy was north of Giglio; also that a torpedo boat had approached the UMBERTO, under cover of darkness, and torpedoed

[1] S. Schichau.

her. Up to this time the Duke of Genoa had been undecided as to the best point at which to attempt the landing. In consequence of the information received from the scouts, he now determined to steer for the mouth of the Volturno, leaving the *Euridice* and *Aquila* behind in order to mislead the enemy. The *Iride* was sent about 10 miles in advance. Later, the *Sparviera* was dispatched towards Fiumicino to decieve the enemy and to lead him to believe that an attempt to land in that neighborhood was contemplated.

In the meantime the scouts of the SQUADRON OF MANŒUVRES were unsuccessful in getting touch with the enemy, and it may be said that their efforts to oppose the invaders ended in failure.

September 3: At 5 a. m. the 4 ships representing the corners of the square anchored off Gaeta, the others remaining underway, ready to attack any of the enemy's ships that might make their appearance.

The landing of the imaginary army went on uninterruptedly, and was finished by midday. The news of the successful landing of the hostile force was communicated by semaphore from Procida and Chiaruccia. It was a success for the attacking force.

In commenting upon the employment of vessels as scouts, "C. M.," in the *Rivista Marittima*, says:

The scouting of the NIBBIO would have had the same result if it had been conducted along the eastern coast of Corsica, and the STROMBOLI, which remained still another day to the west of Razzoli, could have been better employed in the Tyrrhenian Sea. * * * If some torpedo boats had accompanied the NIBBIO, when detailed to follow the convoy, they could have been employed to carry back reports to the commander in chief to great advantage, and a ship of that class, even though chased off occasionally by the enemy, could have kept the latter in sight until their real intentions had been ascertained. It was in this manner that the Duke of Genoa employed his scouts and torpedo boats to the greatest advantage. The important information resulting from their operations reached him just when it was most needed. * * * The news obtained by them was transmitted by means of torpedo boats, the latter showing themselves to be better adapted to that kind of work than the actual duty of scouting. * * * It has been urged that the third theme embodied conditions impossible in actual war, because a convoy composed of such a large number of ships would not take the risk of navigating a sea patrolled by hostile ships, since its great extent and slow speed would expose it to the danger of attacks from which there would be no escape. These observations are quite true, but the vicissitudes of war might necessitate some such attempt. The expedition of Napoleon in Egypt, so brilliantly successful, bears out this assertion. In that case the convoy consisted of nearly 400 ships and moved at a pace so slow that it is difficult to realize it in these days. Passing to the north of Corsica they navigated this very part of the Tyrrhenian Sea, steered to the south of Sicily, stopped at Malta, and reached Egypt unobserved, after having traversed nearly 2,000 miles. Had Nelson only succeeded in discovering the early movements of the convoy, and sent some of his frigates in pursuit he could easily have overtaken and dispersed it.

The vessels taking part in the manœuvres were splendidly handled throughout. No accidents worthy of the name occurred, in spite of the fact that they twice engaged in a close melée, and frequently navigated at night with lights extinguished.

Admiral Amezaga, who was umpire in chief, published the following remarks:

The naval manœuvres have, to a certaint extent, tested our mobilization system, as, for the first time, a large number of ships have been suddenly commissioned, and a certain number of reserves have been called out. The experiment has been, on the whole, successful, as the reserves, with few exceptions, arrived within the prescribed time, and the ships, although not commissioned until July 15, were all ready to take part in the operations by August 1. On the other hand several of the officers in the reserves called upon failed to appear, alleging for the most part, ill health. This is not to be wondered at, as it is not possible to make men enthusiastic who have had their legitimate aspirations in their career brought to a premature close by a limit of age.

If there had been a general call upon the officers of the reserve, there would have probably been better results, and in any case, some indication would have been given of the value of a body in which the country ought to have full confidence, not only in war time, but at any time when exceptional armaments might render a call upon them necessary.

There has been no break down in the fleet to report, although it consisted of 18 squadron ships, 4 torpedo vessels, and 54 first-class torpedo boats; and was manœuvred night and day for a month.

The *Duilio, Lepanto,* and *Re Umberto,* the best specimens of our modern naval architecture, came quite up to the expectations formed of them and the object for which they were built. The steaming radius of our battleships, as in foreign navies, is much curtailed, owing to the necessity of so frequently coaling—a strong advocate of the substitution of hydrocarbons for coal. I am happy to see that, under the administration of Admiral Racchia, steps have been taken to test their value. All our first-class ships have on board a considerable store of naphthaline—the residue of distilled petroleum—which is burnt conjointly with coal. We have at this moment several torpedo boats, which have been fitted to use naphthaline exclusively, and this number is being increased.

The hydrocarbons have an immense future before them in war navies, in consequence of their caloric powers, the ease with which they can be stowed and put on board, the simplicity of their combustion, their cheapness, and the diminution in the number of men where they are in use.

The following is a method of deducing a formula for finding a numerical expression for the coefficient of military power of a ship, by Captain Bettòlo, of the Italian navy:

To be able to establish a comparison between men-of-war of different types, it has been found useful to take as a unit of comparison an ideal ship, which combines in the highest degree the offensive and defensive qualities of a fighting unit. In the expression:

$$B = K.\, f(S)\left\{f(q) + f(d) + f(v)\right\} \qquad (1)$$

S is a function of the displacement; q, of offense; d, of defense; and v, of speed.

In the above expression the displacement is a function of offense, defense, and speed.

Value of functions:

Let Δ = Displacement.

Q = The power of immediate means of offense.

D = The efficiency of the armor and speed, reckoned up to date, and united in the ship taken as a unit of comparison.

The function to be introduced in formula (1) to express the relative value of any vessel may be represented by:

$$f(S) = \frac{s}{\Delta};\ f(q) = \frac{q}{Q}:\ f(d) = \frac{d}{D};\ f(v) = \frac{v}{V}$$

Formula (1) becomes:

$$B = K\frac{s}{\Delta}\left\{\frac{q}{Q}+\frac{d}{D}+\frac{v}{V}\right\} \quad \text{(2)}$$

Value of the coefficient K:

The coefficient K appears in the formula to represent the improvements made in the science of naval warfare, improvements which have rendered possible the utilization of the displacement of ships in order to increase their military value. Such a coefficient expresses also the value of all the offensive and defensive devices adopted by degrees, but which would, if considered individually, render the expression too complicated.

The value of K may therefore be taken as greatest for vessels recently launched, diminishing gradually according to the age of the vessel. A careful consideration of different types of vessels has led to giving the following values to K:

For vessels launched since 1886	K = 1.0
For vessels launched from 1881 to 1885	K = 0.9
For vessels launched from 1876 to 1880	K = 0.8
For vessels launched from 1871 to 1875	K = 0.7
For vessels launched from 1866 to 1870	K = 0.6
For vessels built before 1865	K = 0.5

In case of vessels with wooden hulls the coefficient K should be multiplied by $\frac{2}{3}$.

Determination of Δ, Q, D, *and* V:

We shall consider first the case of a battleship, afterward that of a cruiser.

Displacement.

The greatest displacement yet reached is about 15,000 tons: Therefore in equation (2)

$$\Delta = 15{,}000.$$

Offense.—The greatest offensive power may be considered as proportional to the total energy developed by the guns, and to the number of launching tubes carried by the vessel. Calling E the energy of the guns of the unit ships, e the corresponding energy of the ship whose strength is to be found, N the number of launching tubes of the unit vessel, and n the number of the other ship, we can substitue:

$$\left(\frac{e}{E}+\frac{n}{N}\right) \text{ for } \frac{q}{Q} \text{ in (2).}$$

In considering the energy of the guns we have neglected the rapidity of fire, but assume that all maritime powers are now provided with guns which for equal calibers give about the same results in that respect.

Let E = 100 hundreds of dynamodes.*

In order to take into account the greater destructive effect which may be attained by the larger calibers, on account of striking power, or on account of the greater efficiency of large shells, we shall consider that the utilization of energy decreases as the caliber is diminished in the following manner: Calibers of 45cm (17″.7), 43cm (17″), and 37cm (14″.6) utilize their whole energy.

Guns of 34cm (13″.4) and 32cm (12″.6) utilize 0.9.

Guns of 27cm (10″.6), 25cm (9″.8), 24cm (9″.4) utilize 0.8.

Guns of 20cm (7″.87), and 19cm (7″.5) utilize 0.7.

Guns of 17cm (6″.7), 16cm (6″.3), 15cm (5″.9), and 14cm (5″.5) utilize 0.6.

Guns of 12cm (4″.7), and 10cm (3″.9) utilize 0.4.

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*This value corresponds to an armament of IV 37cm (14.56-inch) Canet guns, or XX Canet guns of 16cm (6.3-inch).

With regard to launching tubes we assume $N=6$, this being the greatest number yet given a first-class vessel. It should be observed, however, that by introducing in the formula the term $\frac{n}{6}$, we shall have large variations in the values of military strength when the n is increased by even a single unit. These variations do not correspond to the reality, because for a first-class vessel the use of the torpedo is purely occasional, and in the comparison of two real battle ships, there is no great discrepancy if one has a stronger submarine armament than the other. For this reason, instead of $\frac{n}{6}$ it is better to use the expression $\frac{\sqrt[3]{n}}{6}$. The cube root of n is chosen, as the number of launching tubes is intimately connected with the quantity of gun cotton on board the ship in question, and the allowance of torpedoes per tube is for similar types of vessels almost the same in every navy. This form of the function will consider, also, the destructive effect of which a vessel is capable, as the efficiency of a submarine weapon is proportional to the cube root of the charge it contains. We have, therefore,

$$\frac{q}{Q}=\frac{e}{1000}+\frac{\sqrt[3]{n}}{6}$$

Defense.—In the defensive power of a ship we shall consider only the side armor, and not express numerically the protection determined by armored decks and other contrivances, because that is allowed for in the value of the coefficient K, representing the progress of naval construction.

The efficiency of the vertical armor depends upon two factors: First, the thickness; second, the extent of surface armored in proportion to the lateral surface exposed to fire.

Let L = The proportion between the length of the armored belt and the length of the vessel,

H = The height of the armor above the water line,

Σ = The thickness of the armor,

$d=f\,(\mathrm{L.\ H.}\ \Sigma)$.

Considering now the thicknesses of armor which are ordinarily employed for the protection of modern ships, and the manner in which armor plates behave on the impact of projectiles, we observe:

(*a*) That armor plates between the thicknesses of 10 and 15^{cm} ($3''.94$ and $5''.91$), besides being able to stop projectiles of small caliber, also lessen the effect of large projectiles filled with high explosives, preventing an explosion inside the vessel by causing it to explode on impact.

(*b*) That the resistance of thick armor plates to the blow of a projectile is a function of a power of the thickness, inferior to the fourth power, but greater than the first. Consequently it will be logical to assign a greater influence to the thickness of 10^{cm}, ($3''.94$), supposing the resistance proportional to the fourth power, and to assume that the excess over this thickness should have an efficiency proportional to the first power.

The term Σ of the above function may therefore be put in the following form:

$$10^2+(\Sigma-10)$$

And we shall obtain:

$$f.\ (\mathrm{L.\ H.}\ \Sigma)=\mathrm{L.\ H.}\ \{10^2+(\Sigma-10)\}$$

Calling l, h and σ the elements mentioned and applicable to any vessel, we shall have:

$$\frac{d.}{\mathrm{D.}}=\frac{l.\ h.\ [100+(\sigma-10)]}{\mathrm{L.H.}\ [100+(\Sigma-10)]}$$

Let us use the following values for the unit vessel of comparison:

$$L=1. \quad H=4 \text{ metres } (13' \, 1\tfrac{1}{2}'') \quad \Sigma=55^{\text{cm}} \, (21\tfrac{1}{2}'')$$

we shall have

$$\frac{d.}{D.}=\frac{l.\,h.\,[100+(\sigma-10)]}{580}$$

Speed.—We may assume the maximum speed as 20 knots for the larger vessels, i. e.,

$$V=20.$$

Expression representing the coefficient of military strength of larger vessels.—From the foregoing, formula (2) becomes:

$$B=K\frac{S}{15000}\left\{\frac{e}{1000}+\frac{\sqrt[3]{n}}{6}+\frac{l.\,h.\,[100+(\sigma-10)]}{580}+\frac{V}{20}\right\}$$

Now, by the definition the unit ship of comparison is one combining in the highest degree offensive and defensive qualities; having the greatest speed and utilizing to the utmost its displacement. When the maximum values of the variable terms are substituted the general formula should become unity. To attain this we must introduce as a divisor the number of terms in the parenthesis, i. e., four.

The formula then becomes:

$$B=\frac{K}{4}\frac{S}{15000}\left\{\frac{e}{1000}+\frac{\sqrt[3]{u}}{6}+\frac{l.\,h.\,[100+(\sigma-10)]}{580}+\frac{V}{20}\right\}$$

To obtain practically acceptable results we must, in the case of cruisers, modify the preceding formula, varying the value of the elements of the cruising vessel which is assumed as a unit of comparison. We must remember that the torpedo, for a cruiser, is a weapon of the first importance. It will, therefore, be proper to substitute for the term $\sqrt[3]{n}$, the term n.

For the unit ship let:

$\Delta=8000$ tons; $E^*=300$ hundreds of dynamodes;

$N=8$; $\Sigma=20^{\text{cm}}$; $L=1$; $H=4$ meters; $V=25$ knots, and we shall have the formula:

$$B=\frac{K}{4}\frac{S}{8000}\left\{\frac{e}{300}+\frac{n}{8}+\frac{l.\,h.\,[100+(\sigma-10)]}{440}+\frac{V}{25}\right\}$$

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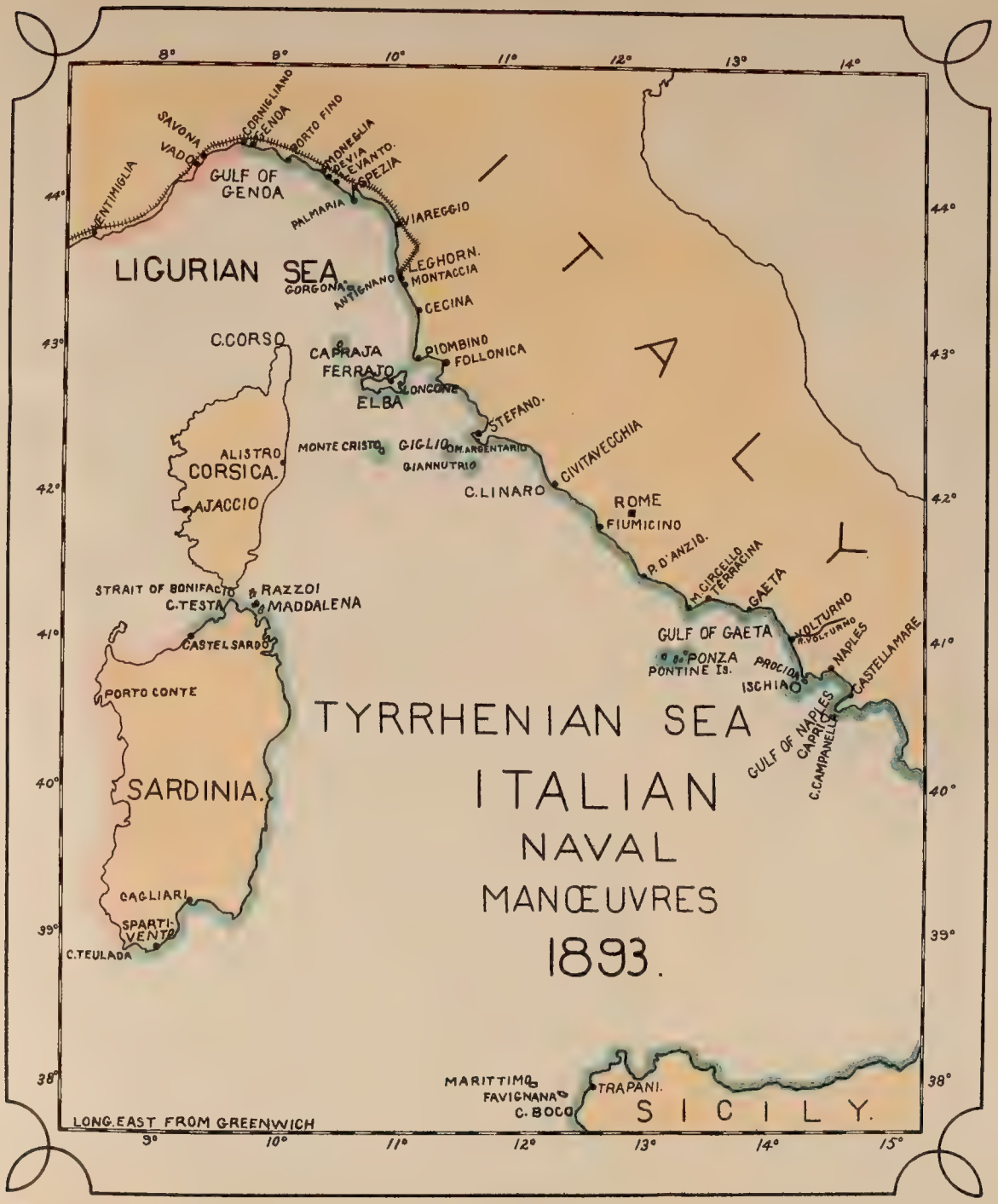
* This value corresponds to two 27^{cm} ($10''.6$) and ten 16^{cm} ($6''.3$) Canet guns of 50 calibers in length.


TYRRHENIAN SEA
ITALIAN
NAVAL
MANŒUVRES
1893.
LIGURIAN SEA
GULF OF GENOA
GULF OF GAETA
GULF OF NAPLES
SARDINIA.
CORSICA.
SICILY.
ITALY
VENTIMIGLIA
SAVONA
VADO
CORNIGLIANO
GENOA
PORTO FINO
MONEGLIA
DOLCEVIA
LEVANTO.
SPEZIA
PALMARIA
VIAREGGIO
LEGHORN.
MONTACCIA
GORGONA
ANTIGNANO
CECINA
C.CORSO
CAPRAJA
PIOMBINO
FOLLONICA
FERRAJO
LONCONE
ELBA
STEFANO.
MONTE CRISTO
GIGLIO
M.ARGENTARIO
GIANNUTRIO
CIVITAVECCHIA
ALISTRO
C.LINARO
ROME
AJACCIO
FIUMICINO
P.D'ANZIO.
M.CIRCELLO
TERRACINA
GAETA
STRAIT OF BONIFACIO
RAZZOI
C.TESTA
MADDALENA
VOLTURNO
R.VOLTURNO
CASTEL SARDO
PONZA
PONTINE Is.
PROCIDA
NAPLES
CASTELLAMARE
ISCHIA
PORTO CONTE
CAPRI
C.CAMPANELLA
CAGLIARI
SPARTI-VENTO
C.TEULADA
MARITTIMO
FAVIGNANA
C.BOCO
TRAPANI.
LONG. EAST FROM GREENWICH
8°
9°
10°
11°
12°
13°
14°
15°
44°
43°
42°
41°
40°
39°
38°

X.

THE REVOLT IN BRAZIL.

By Lieut. C. C. Rogers, U. S. Navy,

Intelligence Officer.

In compiling this article the writer has consulted official reports, the press dispatches, and the current professional literature of our own and of foreign countries. As an eyewitness of the operations from the 2d of November, 1893, to the final surrender in Rio harbor, he feels that it is correct in the main; but due allowance should be made for the uncertainties in news or information that arise inevitably from a state of war.

For six months prior to the outbreak of the naval revolt in the harbor of Rio de Janeiro there had been severe fighting, with considerable loss of life, between two rival factions in the State of Rio Grande do Sul, the one headed by Governor Julio de Castilhos, and the other by Gasper Silveira Martins. The struggle was on the part of the latter and his followers to depose the former. The National Government suported Castilhos and sent large bodies of troops to uphold him.

Admiral Custodio de Mello was the chief organizer and leader of the movement of November 23, 1891, which deposed Marshal Deodora Fonseca from his assumed dictatorship and restored the legal Government, with Vice-President Peixoto at its head. He was afterwards appointed Minister of Marine in the latter's Cabinet.

On the 28th of April, 1893, amid the unsettled conditions due to the revolt in the south, a serious rupture occurred in the Cabinet. The Minister of Finance tendered his resignation and Admiral de Mello surrendered the Marine portfolio, assigning as reasons for so doing the refusal of the Vice-President to adopt his views for a settlement of the civil war in Rio Grande do Sul and a general disposition to manage matters without consultation with him.

The several battles that were fought with varying success on each

side during the summer resulted in no important advantage to either. On the 6th of July, Admiral Wandenkolk, of the Brazilian Navy, took possession at Montevideo of the *Jupiter*, a Brazilian merchant vessel, and, embarking thereon several hundred pretended emigrants, with small artillery, fire-arms, and ammunition, proceeded to the city of Rio Grande do Sul, where he arrived on the 9th. There he seized 2 small Brazilian war vessels and several merchant ships, and issued a proclamation to the personnel of the navy, inviting them to support him. At the same time he prepared to attack the city. The land batteries were too powerful for the *Jupiter*, and after three days of manœuvring she sailed for Desterro. The other vessels returned to their former positions in the harbor or scattered elsewhere. It has been supposed that a simultaneous attack by the rebel army under General Saraiva had been agreed upon, but a failure on its part to reach the coast rendered Wandenkolk's efforts fruitless. Meanwhile the National Government sent the REPUBLICA and the SANTOS from Rio de Janeiro with instructions to capture or sink the *Jupiter*. The REPUBLICA came up with her on the 15th near Caravieiras, on the coast of Santa Catharina, when she immediately surrendered. With officers and crew on board she was taken to Rio de Janeiro, arriving on the 20th. Admiral Wandenkolk was confined at once in Fort Santa Cruz.

Finally, on the 6th of September, the general feeling of unrest and uneasiness culminated in the revolt of a part of the national fleet at Rio de Janeiro. The revolting squadron, under Admiral de Mello, consisted of the *Aquidaban*, *Jupiter*, *Republica*, and a number of merchant vessels that were seized for conversion to armed transports.

For a clearer estimate of the conduct of operations it may be well to recall here briefly certain facts in the situation and resources of Brazil. With an area equal to that of the United States exclusive of Alaska, this great country exhibits the peculiarity that less than half its territory contains nearly all the population. Omitting the States of Amazonas, Para, Matto-Grosso, and Goyaz, there remain 1,157,842 square miles out of a total of 3,119,764 square miles, in which lived 13,222,860 out of the 14,002,335 inhabitants, according to the estimate of 1888. This fact is explained by the physical features of the country. The Amazon, with tributaries in all directions, traverses it from west to east, and between these water courses are great plains covered so thickly with vegetation as to be almost impenetrable. Along the coast are mountain ranges with elevated lands between, and here is the mineral and agricultural wealth of the country. The table land of Matto-Grosso, almost a desert and comprising nearly one-fourth of the area, divides the waters of the Amazon and the La Plata.

Transportation in the interior is carried on by water, and along the coast by mules and railways, the majority of the latter being in the southeast, and one-fourth of the whole in the State of São Paulo. These

railways were built from the coast towards the interior, and their length is limited by the distance of the mountains from the sea. There are two or three exceptions to this in lines running parallel to the coast, but some distance from it. Railway communication northward in the eastern part of the country is almost impossible on account of the great size of the water courses. The San Francisco River, with a basin next after that of the Amazon, rises about 300 miles northwest of Rio de Janeiro, and, flowing northeasterly through a broken country, whose general surface is 2,000 feet above the sea, finally reaches the ocean midway between the two important ports of Pernambuco and Bahia. The greatest extent of its navigation is shut out from the ocean by large falls.

The resources of Brazil are imposing and calculated to insure for her an important future; yet among her imports are coal, iron, large quantities of breadstuffs, and manufactured articles.

Rio de Janeiro occupies a middle position between the ports of the northern and the southern districts. More than one-half the customs revenue of the country is collected there; and it is the political, religious, social, intellectual, commercial, financial, and military center of the Republic.

The State of Rio Grande do Sul has a coast line of about 400 miles, and a population of 665,000. Its chief city is Porto Alegre, situated at the head of the bay of Patos; at the mouth are the ports of Rio Grande do Sul, Pelotas, and São José do Norte. A bar at the mouth of the bay prevents the entrance of vessels drawing more than 13 feet. These ports remained loyal to the Brazilian Government. The State possesses coal mines and important fisheries; its chief industry is the raising of cattle.

Next on the south lies the State of Santa Catharina, with a coast line of 300 miles, and a population of 240,000. A railway transports coal from the valley of the Tubarão to the coast. The chief port is Desterro, on the island of Santa Catharina, and admits vessels of 12-feet draught, but the State possesses five harbors that will admit vessels drawing 20 feet.

The State of Rio de Janeiro has its lower extremity on the Tropic of Capricorn, and consequently lies within the Torrid Zone. It has over 300 miles of coast, and a population of 1,164,438, exclusive of the city of Rio de Janeiro, which constitutes a separate political division and has a population of 406,958. Nearly two-thirds of the coffee product of Brazil finds it way to foreign countries through the port of Rio de Janeiro. The total receipts at the custom house for 1888 amounted to nearly $25,000,000. The value of the exports for eleven months of that year was $54,100,000. The bay of Rio de Janeiro, which is entered through a deep channel, has a shore line of about 180 miles, and anchorage for the fleets of the world.

The State of Parana, which in the latter days of the revolt was controlled by the rebels, is small, with a population of about 200,000 and a coast line of only 75 miles. Its western boundary is the Parana River. The principal port is Paranagua, which has a fine harbor, though a bar at the entrance does not admit vessels drawing more than 18 feet.

The military situation by the 10th of September was as follows:

The shore defenses of Rio Bay, excepting Fort Villegaignon, remained loyal to the Government. In Fort Santa Cruz were mounted two 10-inch Armstrong rifles and several smaller guns; in São Joáó, one 10-inch Armstrong; in Lage, three 6-inch Whitworths; in Fort Gragoata, one high-powered gun, apparently of 6 inches caliber; and in several smaller works, still lighter guns, some of which were field artillery pieces. Including the regiments stationed in Rio de Janeiro, the defensive force numbered between 7,000 and 8,000 men, all armed with Mannlicher rifles.

Of the fleet, there remained loyal the new steel cruiser TIRADENTES, the gunboat INICIADORA, and the old monitor BAHIA, all at Montevideo; the composite gun vessel, PRIMEIRO DE MARCO, and the wooden gunboat, BRACONNOT, of old type, at Bahia; the battle ship RIACHUELO, undergoing repairs, and the cruiser BENJAMIN CONSTANT, completing, at La Seyne, France; together with the composite cruiser PARANAHYBA and the gun-boat CABEDELLO. Of these vessels, the INICIADORA was in dock for general repairs; the TIRADENTES, of 800 tons displacement and 14 knots speed, carried four 4.7-inch rapid-firing guns and seven Nordenfeldts, and the BENJAMIN CONSTANT, of equal speed and 2,800 tons displacement, was designed for twelve 14-centimeter (5.5-inch) guns and a secondary battery of 10 pieces, 8 of which are Hotchkiss revolving cannon. This squadron was to be increased in October by the addition of the AURORA, a 500-ton torpedo vessel of 16 knots speed. Her construction was begun by Scott & Co., on the Tyne, who sold her to Sir W. G. Armstrong, Mitchell & Co. The latter, after putting in a new boiler and adding a forecastle, completed the vessel; and, after hostilities began, they sold her to a Brazilian agent. The vessel is supposed to have gone to Genoa for torpedoes, and then to Brazil.

On taking possession of the *Aquidaban*, Admiral de Mello assumed the title of Commander of the Naval Insurgent Forces of the United States of Brazil. The rebel ships carried a white flag at the fore in addition to the national ensign of Brazil at the peak; the larger portion of the Brazilian fleet had joined Admiral de Mello, who had seized the Nictheroy arsenal, the magazine on Gobernador Island, several vessels of the Frigorifica Steamship Company, besides tugs and lighters, and had established his base on the Nictheroy side of the bay. The officers and crews of the seized ships had gone over to the rebels, and all were engaged in fitting out and organizing the revolting squadron. The latter now consisted of the following vessels:

Name.	Class.	Tonnage.	Armament.
Aquidaban	Battle ship	4,950	Four 9.2″ B. L. R. Armstrong; four 5.7″ B. L. R. Whitworth; six 4.7″ R. F.; two 2″, eleven 1″, and five .45″ Nordenfeldts; five torpedo tubes.
Almirante Tamandaré	Protected cruiser.	4.500	Ten 6″ R. F.; two 4.7″ R. F.; five R. F. and machine guns; 2 torpedo tubes.
Javary	Monitor	3,600	Four 10.2″ Whitworth M. L. R.; four 1″ Nordenfeldts; two machine guns.
Guanabara	Cruiser	1,900	Eight 5.7″ Whitworth M. L. R. in broadside; one 5.7″ M. L. R. on pivot; two 1″ Nordenfeldt; two machine guns.
Trajano	do	1,400	Six 4″ Whitworth M. L. R.; two 1″ Nordenfeldt; two machine guns.
Madeira	Transport	1,260	Two 9-pounder Whitworth B. L. R.
Purus	do	1,260	Two 12-pounder S. B.
Republica	Cruiser	1,300	Six 4.7″ R. F.; four 6-pounder R. F.; six machine guns; 4 torpedo tubes.
Venus	Armed merchant vessel.	1,171	Small R. F. and machine guns.
Jupiter	do	1,124	One 32-pounder; two 6-pounder R. F.; one 3-pounder R. F.; four 12 pounder Whitworth.
Mercurio	do	1.121	Small R. F. and machine guns.
Marté	do	1,121	Do.
Urano	do	1,119	Four 3-pounder R. F.; two 1″ Nordenfeldts.
Meteoro	do	1,082	Two 6-pounder R. F.; two 3-pounder R. F.; two 1-pounder R. F.; four 1″ Nordenfeldts.
Pallas	do	845	Four 3-pounder R. F.; four 1″ Nordenfeldts.
Esperança	do	823	Small R. F. and machine guns.
Marajo	Gun vessel	430	Two 6″ Armstrong; two 57mm Nordenfeldt R. F.; two Nordenfeldt machine guns.
Alagoas	Monitor	342	One 5.7″ (70-pounder) Whitworth M. L. R. in turret.
Liberdade	Gunboat	250	Four 12-pounder Whitworth; four 1-pounder R. F.; four 1″ Nordenfeldts.
Mercilio Diaz	First-class torpedo boat.	106	Two 3-pounder R. F.; four torpedo tubes (Thornycroft.)
Iguatemy	do	106	Do.
Araguary	do	106	Do.
4 torpedo boats	Second-class Yarrow.	50	Two bow torpedo tubes; built for 18 knots speed.

The *Aquidaban* is a masted, double turret, twin-screw ship, built in 1885; citadel and turret armor, 10 inches thick; armor belt, 7 to 11 inches thick; present speed, 7 knots; complement, 355.

The *Tamandaré* is a protected cruiser of steel and wood, ship rigged, and designed for a speed of 17 knots. Her engines were disabled by order of the Government before she was lost to the rebels; one of them was repaired by the latter, but in service her speed did not exceed 4 or 5 knots. Cordite was used in firing the guns, being put up in brass cartridge cases with electric primers. The same material was used for the bursting charges of the shell. The secondary battery of Nordenfeldt guns was removed and placed on board tugs and launches.

The *Javary* was a double-turret, twin-screw monitor, with turret

armor of 13 inches thickness and an armor belt of 6 to 12 inches. Her engines being useless, she was towed from one anchorage to another.

The *Guanabara* was originally a wooden ship-rigged corvette, with a speed of 14 knots. As used by the rebels she was virtually a mastless hulk without motive power, and requiring to be towed in changing position.

The *Trajano* is a wooden bark-rigged cruiser, with a speed of about 7 knots.

The *Madeira* and *Purus* are iron paddle-wheel vessels. The armed merchant ships belong to the Frigorifica and other steamship lines in Brazil. The *Alagoas* is a single-turret monitor, built in 1867, with 4.5 inches of armor, and practically useless.

The revolting squadron controlled the inner harbor to within a limited distance of the shore line, which was defended by artillery, infantry, and police forces. Admiral de Mello was in fact supreme in the harbor of Rio de Janeiro, but on shore he was virtually powerless. Fort Villegaignon and Enxadas Island, where Rear-Admiral Saldana da Gama was on duty as Superintendent of the Naval Academy, declared themselves neutral and remained so for some time. The entire rebel force did not exceed 1,500 men.

At this date, also, England was represented in the harbor by three ships; France, Italy, and Portugal, each by one. Congress supported the Government. Local trade on land continued as usual; foreign commerce was seriously interrupted, if not suspended; desultory firing had been kept up between the naval and land forces, the ships throwing shells at the forts and batteries and at Nichtheroy, resulting in some deaths and considerable damage to private property, only. No interference with railway communication had occurred; but the supply of coal was limited.

The whole standing army of Brazil is fixed by law at 24,877 officers and men. As previously implied, about one-third of this force was assigned to the defense of Rio de Janeiro; the remainder was either in the field in the State of Rio Grande do Sul, or stationed at Bahia, Pernambuco, Santos, São Paulo, and other strategic points.

The naval force, by law, consisted of 3,021 marines, a naval battalion of 990 noncommissioned officers and privates; 300 firemen and 3,000 naval apprentices. Less than one-fourth of the legal effective strength adhered to Admiral de Mello; the remainder was stationed on board the loyal ships and at the naval arsenals in Para, Pernambuco, Bahia, and Matto Grosso.

None of the loyal ships figured in the revolt until near the end, so that at the beginning, the government was virtually supreme on the land, and the rebels, in possessing the *Aquidaban*, were practically so on the sea.

Martial law was declared on the 11th of September for 10 days. During that period, no popular demonstrations were made and very little

interest was manifested in the contest, which was confined to the Army and the Navy, the former supporting the President and the civil authority, and the latter Admiral de Mello.

At 9 a. m., on the 14th, the *Aquidaban*, *Republica*, and *Trajano* took up position before the forts at the entrance to the harbor and opened fire. But little damage was done either to the forts or to the ships. The heavy guns of the *Aquidaban* were not well handled, and many of the shells went wide of their mark. Equally poor marksmanship was displayed by the forts. After a bombardment of six hours the rebel vessels withdrew. On the morning of the 17th, the *Republica* and the *Marcilio Diaz* escaped from the harbor though exposed to a heavy fire from the forts; they were followed the next day by the *Pallas* and another vessel (both of which were protected by cotton bales) and by the torpedo boat *Iguatemy*. The object of these vessels was to support the rebels in Rio Grande do Sul and to hold the island of Santa Catharina, the seat henceforth of what was styled Mello's provisional government.

Repeated firing on Rio de Janeiro resulted in the death of many noncombatants and the destruction of property. Among those killed was an Italian sailor, for whose death, according to the press, the Government paid $50,000 indemnity. Upon the announcement made by Admiral de Mello of his intention to bombard the city, the United States, English, French, Italian, and Portuguese ministers held a conference and advised the commanders of foreign vessels to take measures to prevent such bombardment, in case of necessity. The latter agreed to do so. At the same time a note was addressed to the Minister of Foreign Affairs, conveying to him the unanimous action taken by the Diplomatic Corps with regard to the bombardment of Rio de Janeiro, and requesting that the Brazilian Government abstain from doing anything which would afford the rebels a pretext for such measure. During these days frequent bombardments of Nictheroy occurred, but the rebels did not obtain a foothold.

The 20th and 21st were uneventful. Business showed signs of revival, and the streets resumed their usual appearance. On the 21st, news was received of the appearance of the *Republica* at Santos, and soldiers were sent to São Paulo to reenforce that point. At 3 p. m. next day, heavy firing occurred between Fort Santa Cruz and the *Aquidaban*, *Trajano*, and *Guanabara* and one of the torpedo boats. Neither side suffered much. A shot fell in the city, killing two people. On the 23d, in a bombardment of Santa Cruz by the squadron, the *Guanabara* was struck by a shell. There was more or less firing all of the 24th between Santa Cruz and the fleet.

On the 25th, about 500 Government troops were assembled at the custom-house for the purpose of crossing the channel to Cobras Island, occupied by the marine hospital and guarded by cadets of the Naval Academy, and thus far neutral. The Red Cross flag had been

hoisted on the hospital by order of Admiral da Gama. If fortified, the island would endanger the position of the revolting squadron, and the Government decided to occupy it. The rebels discovered the movement and the *Aquidaban* threatened the first boat load of soldiers who disembarked. Firing began at 4 p. m., and continued half an hour. The batteries on São Bento and Castle Hills were bombarded also, and shells fell in various parts of the city. The troops at the custom-house were soon forced to retire. The attempt was renewed on the 26th. Several shells burst directly over the city and the people fled in every direction. Many buildings were damaged, but the loss of life was small. On the 27th there was a lull in hostilities. Business was suspended in the city and the situation made more critical by an order to the shore batteries to fire on every vessel coming within range. The 28th brought a sharp engagement at the Ponta do Caja, S. Christovao, used by ships and launches of the squadron for obtaining coal. The rebels captured six lighters of coal belonging to the Brazilian Coal Company.

During the 29th a launch was seen near the *Aquidaban*, flying the English man-of-war flag; a boat was sent from the English senior officer's ship to investigate. The launch was found to contain two Brazilian officers, an American named Boynton, an Englishman, and others, together with a torpedo; it was discovered also that the party was preparing to blow up the rebel battle ship. They were taken on board the English cruiser, charged with illegally flying the British flag. Boynton was turned over to the commander of the Charleston, and was subsequently sent to the United States.

The 29th passed quietly. Business houses were closed, owing to rumors of a bombardment. Germans were advised by their consul to retire from the city. Next day the English and French legations notified citizens of their nationalities that the bombardment of Fort Santa Cruz would begin at noon and advised them to retire. A notice advising American citizens of the situation was also posted at the United States consulate. The exodus from the city was general. The attack on Santa Cruz began at 2 p. m. and lasted two hours; it is estimated that 196 shots were fired by the squadron and about 400 by the forts.

On the 1st of October it was known that foreign representatives were trying to arrange for the protection of the city from bombardment. Quiet prevailed generally. By the 4th the news that foreign powers possessing a naval force in the harbor had arranged an accord that the city would not be bombarded, nor provocation given therefor, had restored confidence and a general feeling of security. Banking and other business were resumed, coffee shipments were made, and the streets were again full of people.

Soon after 7 o'clock on the morning of the 5th a part of the revolting squadron took position off the Saude Trapiches, and two launches were sent to capture the coasting steamer *Barão de S. Diégo*, discharging at the Dom Pedro II docks. Fire was opened on the launches, not only

with small arms but from the Castle Hill and São Bento batteries. The supporting ships shelled the batteries, and the engagement was the hottest that had occurred thus far.

On the 6th orders were given to remove the guns from the batteries that had provoked the firing on the city. The previously neutral Fort Villegaignon declared for the revolt on the 9th and displayed the white flag. It was known that the garrison sympathized with the squadron and would join it if forced to take sides. The fort included the marine barracks, containing about 700 men.

On the 10th a general bombardment took place between the fleet and Villegaignon against Forts Santa Cruz, São João, and Lage, resulting in merely a grand display. From this time onward the bombardment of the forts was renewed at frequent intervals. The *Javary* and the *Guanabara* were anchored at the same time off Nictheroy and kept up an occasional fire upon that town to prevent the Government from throwing up fresh works. The rebels did not appear to make any progress, and the daily fighting in the bay and along the shore was attended by no important results. They failed repeatedly in their attempts to land forces.

On the night of the 12th the armed merchant steamer *Urano*, with about 200 rebels on board, succeeded in running the forts. She had been dispatched to Desterro for the apparent object of holding the island of Santa Catharina. Her sides were almost riddled by revolving-gun fire. It is stated that about 40 of her crew were killed and wounded. Injuries to her machinery necessitated anchoring outside the harbor and within range of the outer forts. It has been also said that many of her crew escaped to the shore in boats, where they were captured by the Government forces. This vessel was sent later to Paranagua, after the capture of the latter by the rebels.

About this time Admiral de Mello renewed his threat to bombard Rio de Janeiro, owing to the alleged manufacture of torpedoes at the Government arsenal. There was also a rumor that the city would be declared under blockade.

The 14th was marked by Admiral de Mello's announcement that a Provisional Government of the United States of Brazil was that day established at Desterro, the capital of Santa Catharina, and requested recognition by the principal powers as belligerents. The latter was denied, as the rebels had not established and maintained a political organization that would justify such recognition.

Desterro is situated on Santa Catharina Island, which has a population of 12,000. It was the island only that was held by the rebels, for the remainder of the State on the mainland was loyal to the Republic; apparently so, at least.

The constitution of Brazil provides that the President shall hold his office during four years and shall not be eligible for re-election for the next succeeding term; also that the Vice-President, who shall fill the Presi-

dency during the last year of the presidential term, shall not be eligible to the Presidency for the next term of that office. A bill was passed in the last Congress providing that under no circumstances can a Vice-President be re-elected in case he has served as President for the last two years of the term; and Vice-President Peixoto vetoed the bill. This veto is said to be the immediate cause of De Mello's revolt, the design being to obstruct the approaching congressional and presidential elections. Santa Catharina was never considered steadfast in its political attachments; it is one of the States which gave its adhesion to the Republic only after it was established. When Fonseca dissolved Congress in 1891, the governor of Santa Catharina wrote at once and gave his adhesion to Fonseca's cause. Twenty days later, when Mello started a revolution which resulted in Fonseca's resignation, and Peixoto, as Vice-President, succeeded him, the latter re-established the Congress; Governor Muller was forced to resign and the Vice-President nominated Machado as governor. New State officers were commissioned and a day appointed for a general election, which returned a new State assembly that chose Machado governor. Afterwards, when the revolt broke out in Rio Grande do Sul, Machado took the part of the rebels. He dissolved the supreme court, for which a member of the National Congress from Catharina brought charges against him; under the law, he left the executive chair until his case could be heard before the proper tribunal. Guilherme succeeded him; he was put out by force, and Hercilio de Luz became governor, but the National Congress protested and Guilherme was reinstated. He left the governorship to Christovao Pires, who is now serving. When Mello started the naval revolt, Pires announced himself loyal to the Government. His son, employed in the post-office department, was suspected, however, and was discharged; and the father, as governor, was thought and even reported to be in alliance with De Mello. The Federal Government sent, in October, several officers to raise a force to defend the State, in conjunction with Colonel Martini and Major Firmins who commanded the military stationed there. A Government force of 1,500 men was also dispatched from Paranagua, where ammunition and supplies had been sent from Bahia, for the purpose of driving the rebels from Catharina Island.

Towards the end of October the operations near Rio de Janeiro became more active. The *Jupiter* in trying to pass the forts at the entrance to the harbor on the 20th ran aground, and, though fired upon by the latter in that awkward position, managed to get off undamaged and to retreat to the inner harbor. On the 25th the Government forces at Nictheroy made an attempt to seize the Armação, and thus prevent the further strengthening of the enemy's position in that quarter. The rebels had removed guns and ammunition from that arsenal and had occupied Mocangué Island. On the same day the squadron, aided by Fort Villegaignon bombarded Fort Lage, and a shell from a field gun at Nictheroy blew up 80 tons of powder in a magazine on Mocangué. By

the 27th the rebels had mounted a battery of rapid-firing guns on the same island, and the next day engaged the Government works at Point d'Areia. On the 29th Villegaignon was bombarded heavily by Forts São João and Santa Cruz, the two latter firing 329 shells, the former replying with 59. The next day a rebel force, supported by a gun on Mocangué, landed near Nictheroy for the purpose of turning the national troops, who were attacking the Armação; the Mocangué gun was in action again on the following day, when, to direct attention, two vessels were sent to fire upon the troops behind Gloria Hill and along the Praia do Flamengo. São João and Lage retaliated by bombarding Villegaignon.

November began with continued attacks upon the Government position at Nictheroy. The *Tamandaré*, *Guanabara*, and *Javary*, with the *Aquidaban*, near by, were conveniently anchored for easy bombardment of that city. At 3:37 p. m. on the 3d, the explosion of a magazine on Gobernador Island occurred, by which a large quantity of powder belonging to the rebels was destroyed at once, while the resulting fire caused hundreds of shell to burst for more than two hours. Two English naval officers, a boatswain, and one seaman were killed, and five men were wounded seriously; they were engaged in getting sand near the magazine. The explosion was attributed to Government agents, as it did not occur from gun fire.

The operations during the first half of November consisted mainly of daily duels between the forts at the entrance to the bay and Villegaignon, and between the revolting squadron and the Nictheroy batteries. On the 4th a soldier in front of the Misericordia Hospital fired his rifle at Fort Villegaignon. This episode led to reprisals, for on several subsequent days both Villegaignon and the ships fired with small arms and machine guns at the troops on shore. Several noncombatants were killed in the city. On the 8th the action between the forts was unusually severe; 597 projectiles are said to have been fired by the Government and 177 by Fort Villegaignon. A 10-inch Armstrong rifle was dismounted in Fort São João, and a torpedo boat near the *Aquidaban* was sunk by a shell from a field gun on shore. On the 10th, Villegaignon also dismounted a gun in Fort Lage.

The usual anchorage of the *Aquidaban* up to this time was midway between Nictheroy and Fort Villegaignon. The morning of the 11th found the *Trajano* at anchor between the latter and the wharves of Rio de Janeiro. During the afternoon this vessel directed an active fire upon the city front in the vicinity of the custom-house; a tug from the *Aquidaban* landed a force, who took possession of the custom-house, and from its towers and roof maintained an incessant fire upon the Government forces near by for more than an hour. No advantage was gained, and about 4:30 the landing party disembarked, and while returning to the *Aquidaban* fired upon the city with their boat guns and small arms. A few shots from one of the Nictheroy batteries at an armed merchant vessel lying off the town caused it to withdraw.

Developments during these operations included the personnel of the Provisional Government of the Republic of the United States of Brazil, instituted at Desterro. The naval captain, Frederico Guilhermo Lorena, assumed the post of chief of this Government, which claimed a legislative assembly, a supreme court, and land and sea forces. There were two ministers in the cabinet, one who held the marine, public works, and interior portfolios, and another those of war, treasury, and foreign affairs.

While the damage to property in the city had not been very great so far, yet much danger was apprehended from bombardment. On the 21st of October the diplomatic representatives learned that the Government was manufacturing guns and projectiles in the marine and war arsenals, respectively. Fearing lest these acts would provoke, on the part of the rebels, an attack upon the arsenals and upon the neighboring quarters, especially the Misericordia Hospital, with its 1,500 patients of all nationalities, they submitted the matter to the commanders of the foreign squadrons in the harbor. The latter replied that the work of the arsenals could not be assimilated to the presence of guns in the city, for arms manufactured there were intended for the forts and not for the city; that the Government could not be accused of failing in its promises, for up to that time it had been asked to abstain from direct acts of war only, and that to indicate to the Government a line of action is to become responsible for the consequences that may ensue. The diplomatic representatives thereupon pointed out the new situation to the Government and called its attention to the consequences which an action would bring upon the arsenals and population, while leaving it free to decide upon what it should deem proper to do. The Government maintained that its rights would be singularly limited to the advantage of the rebels if its means of defense were successively considered dangerous, but stated that no preparations of the kind were making in the two arsenals.

Four search lights, located at São Lourenço, Caju Point, Gloria Hill, and Fort São João, were operated by the Government forces, and one on the *Aquidaban* by the rebels. The Gloria Hill light was intended for the service of the police; and to avoid pretext on the part of the squadron for firing upon the city, it was not to aid the forts at the entrance in night attacks upon Villegaignon. Nevertheless, the light being turned one night upon the bay between Fort Santa Cruz and Boa Viagon, Fort Villegaignon fired three times; and again a few minutes later, when it was turned upon the squadron anchored near the mouth of the bay. On the same night a torpedo boat was seen near Flamengo quay approaching rapidly and under the rays of this light. Upon this Fort Villegaignon fired three times with a rapid-firing gun. They were accompanied by machine-gun firing from the launch as far as the point upon which the military arsenal is situated. The same launch returned two hours later, and having been seen by the light when off Santa Lucia quay, she fired on the Gloria light.

The middle of November brought the occupation by the rebels of Fiscal or Rat Island, the site of the custom-house, renewed attempts by the Nictheroy garrison to prevent the insurgents from drawing further supplies of guns and ammunition from the Armação, the commissioning of the *Tamandaré*, the throwing up of new defensive works on the water front of the city, and developed conclusively Admiral da Gama's leaning toward monarchism and his sympathy with the rebels. A remarkable feature of the conditions at the beginning of the revolt was the attitude of neutrality maintained by Fort Villegaignon and continued for several weeks; and also that of the naval school and arsenal situated upon Cobras Island and commanded by Admiral da Gama. It is said that the latter did not hesitate on all occasions to proclaim himself in favor of re-establishing the Empire, and that he declined for that reason to accept appointment from the Republic; and that his sympathy with the rebels arose from a hope that results favorable to the restoration of the monarchy might follow the overthrow of the existing government. His status of neutrality was of great value to the rebels, and this fact began to be felt keenly at this stage of the war. There was talk of taking steps to subject his command to Government authority, as such action would cause him to declare openly his intended course.

On the 16th of November the State of Pernambuco was placed under martial law. Three members of Congress were imprisoned and the newspapers in the city of Pernambuco were suppressed; the peace there was not disturbed, however.

Fusillades occurred almost daily between the Government troops and the enemy's launches, especially along the city front. These, with firing by the former upon the garrison of Fort Villegaignon, led once to machine-gun and small-arm fire from the fort and the *Aquidaban* in the direction of the city.

On the 22d a shell from Fort São João sank the monitor *Javary*. During the forenoon an occasional shot was fired by the *Trajano* at the Nictheroy batteries, and at noon heavy firing began between Forts Santa Cruz, São João, and Lage on the one side, and the *Aquidaban*, *Javary*, *Trajano*, and Fort Villegaignon on the other. At 3:40 it was evident to spectators that the *Javary* was sinking, for several tugs and launches had been sent to her assistance, and had endeavored to tow her into shallow water. At 3:45 she careened to starboard, and went down at the man-of-war anchorage near Fort Villegaignon. Nictheroy had been the special prey of this vessel since the revolt began, Fort Gragoata and the batteries between it and the Armação having withstood its bombardment without surrendering. The *Javary* had been frequently struck by projectiles from the batteries, and sympathizers with Mello's cause have claimed that her loss was due to a leak caused by the shaking from her own fire. There is not sufficient evidence to sustain this theory.

The 24th opened with the bombardment of Fort Villegaignon by Santa Cruz and São João; a shell from the latter dismounted a heavy gun in Villegaignon, and added much to the credit already gained by its gunners in sinking the *Javary*. One of the rebel launches was sunk on the same day by a well directed shot from a battery in Nictheroy.

On the 26th the Government forces at Nictheroy occupied the Armação, and about 4 p. m. were fired upon by the *Trajano* and the *Jupiter*. The next day the attack was renewed by these vessels at 2 p. m., with the assistance of the *Aquidaban* and several launches. The brunt of the attack was borne by the launches, in which was an armed force that handled their small vessels with great skill and exhibited signal bravery. The supporting ships used their secondary batteries in the main, firing occasionally a shell from the heavier guns. As Fort Gragoata was annoying the *Trajano* with its single high-powered gun, the *Aquidaban* came to the support of the latter with two shells from her forward turret guns, which did no particular damage. The rebels were repulsed, but the presence of their ships prevented the Government forces from occupying the Armação. Firing ceased at 5:30. At 9:15 the *Trajano* fired 10 shots at the arsenal, the *Aquidaban* holding her search light upon it in the meantime. The *Jupiter* directed an occasional shell after midnight, and at noon the next day the *Trajano* came to her assistance, the two vessels maintaining a slow fire till dark.

The ships then withdrew, to begin again, at 8 o'clock, a vigorous attack in which the *Aquidaban* took part, frequently turning her searchlight upon the arsenal and firing her 6-inch battery. During the 29th and 30th the squadron was increased by the *Pereira da Cunha* and the *Guanabara*, the latter being towed into position under cover of darkness by a tug; an armed force in launches under cover of a vigorous bombardment by the combined ships was unable during these forty-eight hours to reduce the place. In the course of the action on the first day, a tug engaged in towing the *Trajano* was struck by a shell and sunk; and during the second, the *Guanabara* succeeded in penetrating the north wall of Fort Gragoata, and received in reply a shell that burst on her deck.

During these operations the transport *Madeira* was set on fire by the bursting of a shell, and the *Trajano* attempted to secure to a coal wharf near the Armação, but was unable to do so on account of the fire from a battery; the *Pallas*, belonging to the rebels, was wrecked near Santa Catharina, while the Government received at Pernambuco an addition to its fleet in the torpedo vessel AURORA, just arrived from Europe and renamed GUSTAVO SAMPAIO.

The 1st of December was marked by the most important event in the early part of the war. It was the departure of Admiral de Mello from the Bay of Rio de Janeiro. On the 29th of November he notified the foreign naval commanders, through his flag lieutenant, that he was preparing to leave, and at one o'clock of the first morning of December he

steamed out of the bay in his flagship, the *Aquidaban*, accompanied by the *Esperança*, an armed transport. The latter was in advance of the flagship, and they passed the entrance to the bay under the full glare of São João's search-light and a blaze of fire from the forts, which was hotly returned by the *Aquidaban* and the supporting fort, Villegaignon. The battle ship made every possible endeavor to draw upon herself the beams of the search-light in order to facilitate the exit of the transport. The *Aquidaban* received a shell in one of her coal bunkers and several small projectiles fell on her deck, but no one was killed or wounded, and the ship was not seriously damaged. Another shell penetrated the side of the *Esperança*, injuring her machinery, killing the chief engineer and wounding several men. The two ships sailed south to Ilha Grande, a quarantine station 60 miles from Rio, where they filled with stores and seized all the Government funds available. Thence the *Esperança* proceeded to Desterro.

The effect of de Mello's change of base was to confirm the theory that he had agreed with Admiral da Gama in regard to the latter's uniting with him in the overthrow of the Government; and it was furthermore believed that in event of success Da Gama's proposition to reestablish the Empire would be submitted to the people. Admiral da Gama had been actively engaged in fortifying Cobras Island, and the current rumor was that in a few days he would assume command of the revolting forces in the bay.

During the afternoon of December 3, the *Almirante Tamandaré* took up the *Aquidaban's* anchorage between Fort Gragoata and the custom-house, and joined occasionally in firing upon the Nictheroy batteries, which, with the bombardment of Villegaignon by the Government forts, were the principal daily events for nearly the first half of the month.

On the 9th Rear-Admiral Saldanha da Gama declared in favor of a restoration of the Government as it existed before the Republic, and joined the cause of the rebels. From his manifesto it was evident that the latter now proposed to change the form of Government and restore the Empire, subject, however, to a ratification by the people. It was understood, in fact, that such ratification would be merely a matter of form, as the moral effect of a victorious armed force would alone insure the result. The manifesto was opposed by the press and by the people in nearly every State, and its reception was not at all flattering to the monarchical cause. The admiral's appeals to the officers of the Army also met with refusals and expressions of loyalty to the Republic. Among the former officers under the Empire, and those who received social or other distinction from it, there was much sympathy with the restoration movement; they had but little influence, though, with the masses, and were apparently inactive.

During the 9th also, the merchant vessels, complying with an order by the Government, moved from their anchorages near Cobras, Enxadas, and Santa Barbara islands; the Government's intention to attack the

latter by an expedition from the main land was also known. Tons of sandbags and steel plates had been put in position to defend the landing near the marine arsenal, and rapid-firing guns trained upon Cobras, which was commanded as well by batteries on Santa Teresa and other hills. Six hundred men formed the garrison of the island, and the *Guanabara* lay at anchor near it. Late in the afternoon the *Jupiter* and other transports communicated with the *Tamandaré*, and proceeding towards Cobras anchored in supporting positions of each other and of the island. At 10:30 p. m. sharp small-arm firing began between Cobras Island and the city front, increasing gradually to heavy firing intermingled with frequent discharges from the batteries of the transports and from the rapid-firing guns of Cobras Island and of the city. The action was well sustained by both sides for more than an hour, when the firing became less frequent. At 11:45 the *Tamandaré* fired a 6-inch shell in the direction of Cobras and of the city; and at midnight, the Government force having been repulsed, the battle ceased.

Three days later, the *Guanabara* and *Trajano* were at anchor near Cobras Island; but the *Tamandaré*, *Jupiter*, and three transports were lying in the northeastern part of the bay near Gobernador Island and out of reach of all guns in the forts. They were joined in a few hours by another transport and two torpedo boats. The field of operations was now extended. From the new anchorage, armed tugs supported by one or more transports were sent out daily to engage the Government forces along the city front, especially at the marine arsenal; the afternoon duels were increased by this, by small-arm firing between Cobras Island and the marine arsenal, and by exchange of shell between the former and Gragoata.

This new movement was evidently a thorn in the side of the Government, for on the 14th Gen. Silva Telles, with an estimated force of 300 men, attempted to capture Gobernador Island. The rebels were not strong enough to occupy it, but had utilized it in various ways. Admiral da Gama landed 200 men and 4 field guns and supported their defense by the fire of his ships; but they were forced to withdraw after a short engagement. The erection of batteries in places suitable for harassing the revolting squadron was at once begun; one of them was unsuccessfully attacked by a rebel transport about 4 p. m. on the 17th. Closely following the occupation of Gobernador were the seizure of Bom-Jesus Island, where the rebels kept their fresh-water supply, and the virtual stoppage of attacks by transports upon the marine arsenal and the city front north of it. The rebel ships began to seek shelter from the fire of the land batteries by lying close to the foreign merchant vessels, with the result that the latter were promptly ordered by the Government to move.

At 4:30 p. m. on the 21st, Fort Gragoata, the Nictheroy, and the Armaçao batteries opened fire on the *Tamandaré*, *Jupiter*, and three armed launches accompanying them; at the same time, Point d'Areia battery

bombarded the rebel position on Mocangué Island while supporting the advance of the Government troops for the capture of the latter. The guns of the *Tamandaré* were directed at Armação and did excellent shooting; and the firing on both sides was very rapid with both large and small calibers. At 6 p. m. the island was in the possession of the Brazilian troops. The capture of Mocangué was followed by that of Engenho and Conceição islands, the aim of the Government being to surround the rebels so that they could be reached by artillery in any part of the bay. From this date till the end of the month, Mocangué was heavily shelled by the *Tamandaré* and the *Jupiter;* but the Government was daily mounting more guns around the harbor, and new batteries at Nictheroy, at the Armação, and on Gobernador Island so hemmed in the enemy's squadron that the waters in their vicinity were the scene of the hardest fighting till the close of the year. During the engagements of this period the *Tamandaré* was struck several times, but never seriously injured.

During this month foreign nations were represented in Rio harbor by warships, as follows: The United States, by the "Newark," "Charleston," and "Detroit;" Austria, by the "Zrinyi;" England, by the "Sirius," "Beagle," and "Racer;" France, by the "Magon;" Holland, by the "De Ruyter;" Italy, by the "Etna," "Giovanni Bausan," and "Dogali;" Portugal, by the "Mindello" and "Alfonso de Albuquerque;" and Spain, by the "Cristobal Colon."

After assuming command in Rio harbor, Admiral da Gama's first efforts were to prevent all merchandise from reaching either the custom-house or the shore. It was for this purpose that the fire of Cobras Island and of the armed transports was directed upon the marine arsenal and the city front in its vicinity. He also expressed his intention of firing upon the city "under imperative circumstances;" and projectiles of various calibers fired by his forces fell into the city and made numerous and innocent victims of several nationalities. On the 24th of December he asked for recognition as a belligerent; and about the same date, claiming that the heights of Rio were fortified, he notified the foreign naval commanders that at the first shot from such points his vessels would reply with heavy artillery. In reply, he was informed that the facts enumerated in his note did not justify the threat of a bombardment, and that the commanders would hold to the attitude taken with Admiral de Mello.

The last operation of the month and year was the bombardment by Fort São João of Enxadas Island, under the belief that the rebel hospital there was used as a workshop for purposes of war. The falling shell forced a hospital ship and a steamer containing political refugees and the families of rebels to change their anchorage.

The end of the year found Admiral da Gama in straits, especially for men and, perhaps, ammunition. The *Aquidaban*, *Republica* and other ships were in the south, presumably to attack Santos and other

places. Reinforcements expected from Rio Grande do Sul or Santa Catharina had not arrived. Each succeeding day found the Government stronger on the shores of Rio Bay. The people had not flocked to the imperial standard in response to his first manifesto; he accordingly issued a second, denying that it was his purpose to restore the monarchy, and proclaiming that "the idea of a plebiscite" was "to consult the people as to the form of republican government which they prefer to carry out their glorious destinies." This manifesto failed of its purpose also. Friends of the Republic regarded it as a passing manœuvre to win support to the rebels' cause. While not gaining for the revolt any new republican friends, it displeased many of its former supporters, especially the monarchists, who considered it a backdown on Da Gama's part. Unsigned notices were also circulated thoughout the city, in which the charge was made that the Government had been hiring North American mercenaries to fight against Brazilians.

The 1st of January, 1894, found the rebels beginning a desperate resistance to the steady advance of the Government forces on the most important headlands and islands of Rio Bay. After losing Bom-Jesus, they had established a water and provision depot on Paqueta Island, in the northern part of the bay.

On the 3d a sharp fight took place on the island of Engenho. The Government occupied the place for the purpose of cutting off the access of the rebels to the island of Paqueta, and had mounted a 70-pounder Whitworth gun and a Krupp 3.5-inch fieldpiece to command the passage, and to prevent steam launches carrying provisions from Paqueta to the rebels. The garrison consisted of 7 officers, 120 men, and 25 civilians in the employ of the Government. About 10 a. m. the *Trajano*, *Jupiter*, and two of the armed launches began shelling the island. This continued until 7 p. m., and the fire was returned from the Whitworth and Krupp guns. At 7 o'clock 200 men were landed from the ships for the purpose of storming the place. The garrison opened a heavy rifle fire on the landing force, and for a moment the advance was checked, but only for an instant. Then some of the officers ran forward, and the men at once followed them up the hill to the guns. In ten minutes both guns were captured and some of the soldiers made prisoners, the remainder rushing away into the woods. The rebels then sent two launches round to the back of the island to prevent any escape to the mainland, and dispatched search parties to seize everybody they could find. In all, 5 officers and 63 men were captured; 13 dead bodies were counted and 5 wounded soldiers were found, the latter being removed at once to the hospital on Enxadas Island. Twenty-five civilians in the employ of the Government were removed to the ships, and a large quantity of ammunition and other stores were seized. The rebel loss was 2 men killed and 5 wounded, a loss quite out of proportion to that suffered by the Government, and this is the more remarkable from the fact that the soldiers were behind trenches and well under cover. The

following day the Government sent up a body of troops to the mainland at the rear of the island and opened a heavy fire; the *Jupiter* and some launches went close in and replied vigorously to this, and the troops were finally withdrawn without making any further attempt to land on Engenho. A few days previous to this affair the Government attempted to occupy the island of Boqueirão, where a large deposit of ammunition was placed. The rebels repelled the attack and inflicted severe loss on the Government troops. Next day Admiral da Gama removed all the service ammunition on board the various ships and caused what was left in the deposit to be blown up, much of this being rifle ammunition suited only to the weapons the troops were armed with, and useless for the rifles served out to the navy. The rebels still remained in possession of Boqueirão, and had a garrison of 60 men on the island. These two little successes did much to raise the spirits of the officers and men in the rebel ranks, and they appeared quite determined to make every effort to retain possession of the harbor.

The rebels succeeded in occupying Conceiçao Island with 250 marines on the 9th. Some fighting began on the 1st and continued almost daily for the possession of Vianna Island. On the night of the 10th the launches and the *Tamandaré* attacked the national forces on Mocangué Island, while the Government troops and forts opened on Vianna. The firing continued from 10 in the morning until 3 in the afternoon, but with no material damage to either side. Meanwhile the commanders of foreign squadrons gained positive information that several large guns had been mounted on the Morro do Costello in the city of Rio de Janeiro; under such circumstances they no longer considered themselves under obligations to prevent a bombardment.

Up to the time that Admiral de Mello left the bay no very serious interruption of commerce had occurred. Since the succession of Admiral da Gama to the command many impediments to its free operation had been experienced, owing to his efforts to stop the passage of goods to the custom-house. Several American ships that went to the docks on their own responsibility, and with the consent of the Government, had discharged and taken on cargo without interference. Some German and other ships had also proceeded without interruption. Such was the status of foreign commerce on the 12th, in the early morning of which the *Aquidaban* returned to the bay, running past the forts before they had been aroused, and without being touched. When three miles up the harbor, however, two shells from a gun at the Armaçao hit her, one passing through the wardroom and another through the forward part of the superstructure and resulting in the wounding of two men. Admiral de Mello was not on board, having shifted his flag to the *Republica* and remained in the south.

At 4 a. m., on the 16th, the *Aquidaban* took up position off the northern end of Mocangué Island and, firing with her 5.7-inch battery and machine guns, soon drove the national troops from their intrenched

position. At the same time she covered the landing of an armed force in three launches, who, after three hours of stubborn fighting, succeeded in recapturing the island and in turning its guns upon the troops at Ponta d'Areia and at the Armaçao. Three Krupp fieldguns, a 70-pounder Whitworth, 200 rifles, and a quantity of ammunition thus fell to the rebels.

At about the same time Admiral da Gama learned that the Government contemplated an attack on Conceiçao Island; the result was that the rebel garrison there was strengthened by 250 marines. On this account the Government troops were greatly surprised when they made their attack and were repulsed with the loss of about 100 men, to 20 killed and wounded on the opposing side. A gun mounted on this island and another on the southern summit of Mocangué commanded the railway to the interior, the Nictheroy gas works, and all prominent points in the vicinity.

By this date the United States squadron in the bay had been strengthened by the "San Francisco" and the "New York."

After the 16th there were few happenings of any importance during the rest of January between the Government and rebel forces in Rio Bay. The return of the *Aquidaban* to the bay gave renewed confidence to the latter and made them more aggressive. Their repeated assaults upon Nictheroy had been repulsed thus far, but great damage had resulted to both life and property; and though the position gained at Mocangué was of no particular importance, yet their attack had resulted in a severe defeat to the Government and the abandonment of the island.

Generally speaking, the rebel position from this time till the end of the revolt was as follows:

The *Aquidaban* and the *Tamandaré* anchored usually near Engenho Island; the *Trajano*, *Guanabara*, and flagship *Liberdade* lay off Saude Point, to the westward of Enxadas Island; and the armed transports sought shelter among the foreign merchant vessels. Fort Villegaignon was in ruins on the sides toward Forts Santa Cruz, Lage, São João, and Gragoata, although six or more guns were still mounted; the guns on the city side were undisturbed. There were a few guns of large caliber—6-inch, perhaps—and several rapid-firing guns mounted on Cobras Island; to these, in February, the battery of the *Guanabara* was added. Enxadas Island was used for the sick and wounded, the hospital being located there. Paqueta Island was a place of refuge as well as a supply depot, and Mocangué, Velha, Coal, Vianna, and Conceição were held on account of the large amount of coal on the three last named.

Till near the end of the month armed tugs or launches steamed in the early morning or toward dusk along the city front and fired toward the shore, and were apparently regardless of their aim. Such haphazard firing along the water front rendered it unsafe for merchant ships to lie at the docks, and was done intentionally, as previously implied.

From this period, also, till the end of the revolt, the batteries on Gobernador Island, at Areia Point, and the Armação fired daily at the *Aquidaban* and *Tamandaré*, if anchored near Engenho Island; Forts Santa Cruz, São João, Lage, Gragoata, and São João Baptista, with the Nictheroy and Armação batteries, directed their shots at Fort Villegaignon or Cobras Island, and short but sharp fusillades occurred at any hour of the day or night between the Armação, Areia Point, Morro Areia, and São Lourenço batteries on the one side and the armed tugs or men engaged in handling coal on Conceição, Coal, or Vianna islands on the other.

The victories of the Government forces in Rio Grande do Sul culminated on the 8th of January, when the siege of Bage was raised. The rebels disbanded or fled, without ammunition and poorly horsed. The reports show that incessant firing was kept up for eighteen days, during which the Government losses were 36, while the rebels lost over 400; besides, it is claimed that 500 deserted from the Uruguayan bands.

Meanwhile, during the course of the revolt, the Brazilian Government was assembling a squadron at Pernambuco. The PARANAHYBA was fitting out there, as well as the SAN SALVADOR, an armed merchant vessel. It has been seen already that the AURORA had arrived there; she brought with her 10 or 12 Schwartzkopf torpedoes, purchased through agents from the factory at Venice.

A London agent had purchased from Schichau 5 first-class torpedo boats that were built about five years ago for the Italian Government, but were not accepted. They were designed for a speed of 22 knots. They left the works at Elbing about the middle of November with 18 Whitehead torpedoes of old pattern on board, which had also been bought in Germany; going by way of Maderia, they reached Pernambuco in January. Each boat was 144 feet long, had a displacement of 120 tons, and was armed with two 37-millimeter Hotchkiss revolving cannon.

These numbers had been further increased by the arrival, during the past two months, of the MOXOTO, PIRATINY, NICTHEROY, and ANDRADA from the United States.

The MOXOTO is a third-class Yarrow torpedo boat of steel, that was purchased in England and equipped in New York during October and November. She is 60 feet long, has 9 feet beam, and besides carrying two Howell torpedoes, is armed with two 1-pounder Hotchkiss R. F. G.

The PIRATINY was formerly the well-known Ericsson torpedo boat "Destroyer." She was purchased for the Brazilian Government in October, along with the Ericsson submarine gun and 6 projectiles. Her length is 130 feet, and beam 12 feet. In addition to a central pivot Howell torpedo tube mounted in the waist, she carries two 1-pounder Hotchkiss R. F. G. Her probable speed is 10 knots.

The NICTHEROY is a steel screw steamer, formerly known as the "El Cid," and built by the Newport News Shipbuilding Company for the Morgan Line in 1893. She is 389 feet long between perpendiculars,

has a beam of 48 feet, a load draught of 22 feet, and a displacement of 7,080 tons. Her coal capacity is 3,500 tons. The engines are of the vertical triple-expansion type, with a horse power of 4,000, and capable of developing 17 knots speed.

The battery consists of one 15-inch pneumatic gun, mounted on a training circle forward of the pilot house, and training from beam to beam by the bow; one 4.7-inch R. F. G., 43 calibers, 55-pound shell, on poop; two 3.94-inch R. F. G., 42 calibers, 33-pound shell, on forecastle; eight 6-pounder R. F., seven long 1-pounder, and two short 1-pounder R. F. G.; two 37-millimeter revolving cannon; four Howell automobile torpedoes; and one Halpine storage-battery torpedo. The 4.7-inch gun has an arc of fire of 270 degrees, and each 3.94-inch gun about 165 degrees, the pneumatic gun limiting each of the latter to its own side of the ship. The 6-pounder R. F. G. are mounted on the gun deck as near the sides of the ship as the shields permit with the ports closed. The 1-pounders are mounted on the spar deck and on the tops of deck houses. The tubes for the Howell torpedoes are on the gun deck, two foward and two aft.

The after magazine contained the ammunition for the 4.7-inch and long 1-pounder guns and part of that for the 6-pounders; the forward one, the remaining ammunition for the 6-pounders and all for the 3.94-inch, 37-millimeter, and light 1-pounder guns. Five torpedo heads were also stored in each magazine. The gun cotton shells were stored in the gun cotton magazine. The ammunition carried when this vessel sailed for Rio de Janeiro was as follows: 50 rounds for the 4.7-inch R. F. G., 100 rounds for each 3.94-inch gun, 1,419 rounds for the 6-pounders, 540 for the heavy 1-pounders, and 600 for the light 1-pounders, 10 shells for the pneumatic gun, 10 Howell torpedoes, and 1 Halpine.

The NICTHEROY carries two second-class torpedo boats, the POTY and the INHANDUAY. The POTY was formerly the yacht "Javelin," built by Herreschoff, and converted into a torpedo boat. Her length is 126 feet, beam 12 feet, and draught about 3 feet; speed, 18 knots. On the forward deck is a central-pivot Howell torpedo tube, and a light 1-pounder R. F. G. is mounted on the iron conning tower. Her displacement is 30 tons. The INHANDUAY, 17 tons, was formerly the canoe-shaped yacht "Feiseen," built by Gardner & Mosher. She has a record of 30.6 statute miles, or about 25 knots per hour. Her length is 90 feet, beam 10 feet, and draught 3 feet. Her fittings and armament are like those of the POTY.

The NICTHEROY is fitted also with an Edison Ideal dynamo plant. The original intention in converting this vessel from a freight to a war ship was that the work should be of a temporary character in order to save time. As the work progressed, it was made permanent, because in nearly every case it was as good as possible, though the period of conversion was only two weeks; and the general character of the workmanship is such as to make the NICTHEROY a most formidable war vessel. Her supply of coal, provisions, and water enables her to keep the sea for 5 months without touching port.

The ANDRADA, also an unprotected cruiser, was formerly the "Britannia," an English passenger steamer built in Bergen, Norway. Displacement, 2,600 tons; length, 270 feet; beam, 34 feet; draught, 19 feet; engines of the vertical, direct-acting, triple-expansion type; horse power, 3,600, with forced draft; speed, 17 knots; coal capacity, 600 tons. Her battery consists of two light 4.7-inch Armstrong R. F. G. on the forecastle; two 14-pounder Hotchkiss R. F. G. on poop; six 6-pounder R. F. G. (four on the main and two on the hurricane deck); six light 1-pounder R. F. G. (two on main and four on hurricane deck); two central-pivot Howell torpedo launching tubes in the waist; two bow Howell torpedo launching tubes, and one Sims-Edison torpedo stowed on the hurricane deck abaft the foremast.

The arc of fire of the starboard 4.7-inch gun extends from 2 points on the starboard quarter to the port beam by the bow, and that of the port gun extends from 2 points on the port quarter to about 1 point on the starboard bow, and from the starboard beam to about 1½ points abaft it. That of the starboard 14-pounder extends from astern to about 3 points on the starboard bow, and from about 2 points forward of starboard beam to the starboard beam, while that of the port 14-pounder extends from the starboard beam to about 3 points on the port bow by way of the stern.

All of the 4.7-inch ammunition, part of the 6-pounder, and four torpedo heads are stored in the forward magazine; all of the 14-pounder, the greater part of the 6-pounder, and all of the light 1-pounder ammunition, with 4 torpedo heads in the after. The ammunition carried by the ANDRADA on sailing was: 200 rounds for the 4.7-inch guns, 250 for the 14-pounders, 1,332 for the 6-pounders, 1,400 for the light 1-pounders, 8 Howell torpedoes, and 1 Sims-Edison. Eighteen days were required to convert the ANDRADA into a war ship. Upon leaving New York she was called the AMERICA.

After arrival, the fitting out of these vessels was continued, and their complements were filled, organized, and drilled; and the name of the AMERICA was changed to ANDRADA.

From Pernambuco, on the 20th of January, the NICTHEROY and two other vessels sailed, apparently for the south.

The absence of Admiral de Mello from the scene of hostilities gave currency to rumors that he had abandoned the rebels' cause, and that Admiral da Gama had assumed command of the entire force. Another report stated that he was at Desterro very ill with beri-beri, or suffering from wounds received while leaving the harbor on the 1st of December. It was known definitely that beri-beri was prevalent on board the *Aquidaban* at the time of her departure.

In the south the rebels had occupied Curitiba, and after two hours' fighting had captured Paranagua. The garrison yielded to superior force and agreed to join the revolt. A large supply of rifles, 6 Krupp guns, and 26,000 rounds of ammunition were captured. The *Urano* served as a partial protection for the harbor.

Up to the 26th of January, commercial operations in the harbor were carried on without serious interference with foreign interests. The English had had trouble, owing to Admiral da Gama's orders preventing the landing of coal, and which, of course, caused loss to merchants engaged in that trade. At a conference of the foreign naval commanders, it was decided that they would oppose the attempts of the rebels to prevent the landing of coal; but as several were without instructions authorizing the use of force, positive action was delayed until they could communicate with their governments.

That Admiral da Gama believed his success to be dependent upon cutting off the maritime trade of Rio de Janeiro now became evident. During the course of the 26th, a battery at Cobras Island fired at an American vessel that was heading for the docks. Again, on the 27th two other ships of the same nationality were fired upon by the Cobras battery and the *Trajano*. Rear-Admiral Benham. commanding the United States Naval Force on the South Atlantic station, called Admiral da Gama's attention to these facts and asked that immediate orders be given to prevent their recurrence. In reply, the latter stated that blank cartridges only had been fired, and as a warning to vessels approaching a danger zone. The master of one of the vessels certified that his men were driven from the wheel by bullets flying over their heads, and that the rigging of his vessel had been cut. Thereupon Admiral Benham demanded that peremptory orders be given forbidding the firing of blank or other cartridges at American vessels, and that he should be informed by Admiral da Gama of the promulgation of such orders. He also notified the latter that American ships would be protected by force unless such firing was stopped. The rebel admiral still insisted upon his right to warn by a shot all vessels approaching the wharves within limits established by himself.

On the 27th the masters of the American vessels "Amy," "Goodnews," and "Julia Rollins" notified Admiral Benham that they wished to haul in to the wharves near Saude Point on the morning of the 29th. Admiral Benham accordingly informed Admiral da Gama that such movements of these vessels would occur, and that if fired on they would be protected by the United States squadron. The situation now became serious, and at 6:15 p. m. of the next day the "New York" and the "Detroit" cleared for action. At daylight next morning the "San Francisco," "Charleston," and "Newark" also made all preparations for battle. In the plan for the protection of American ships it had been ordered that, if hostilities could not be avoided, the "New York," Capt. J. W. Philip commanding, and the "Newark," Capt. Silas Terry, should attack the *Aquidaban*, *Tamandaré*, and the transports anchored near Engenho Island; the "Detroit," Commander W. H. Brownson commanding, and the "Charleston," Capt. H. F. Picking, should engage the *Trajano*, *Guanabara*, *Liberdade*, and their tugs or launches, while the "San Francisco," Capt. J. C. Watson commanding, would silence Fort Cobras.

At 6 a. m., on the 29th, the United States squadron was underway. The "Detroit," which was assigned to the best position for the ends of protection, had orders to fire back if the merchant vessels were fired upon. While proceeding to her position she slowed down for 20 minutes on account of a spirited musketry and rapid-gun fire between 3 rebel launches and the shore batteries of the Saude water front. After starting ahead again she steered midway between Cobras and Enxadas islands and steamed towards the *Trajano*, *Guanabara*, and *Liberdade*, moored to buoys, a short distance to the northward and westward of Enxadas. Two armed tugs, three launches, and a torpedo boat lay in easy supporting distance of the parent ships.

As the "Detroit" neared the rebel ships, the *Trajano* fired a musket shot over a small boat engaged in carrying a warping line from the American bark "Amy" to a wharf about 100 yards distant. The "Detroit" replied with a shell from a 6-pounder R. F. G., which, as intended by the gun-captain, struck the water about six feet forward of the rebel's stem; the distance between the two ships was then about 60 yards. As the "Detroit" passed the starboard beam of the *Trajano*, Commander Brownson hailed her and declared that he would return her fire, shot for shot, and, if necessary, would sink her. The *Trajano* then fired a blank charge to leeward by way of protest.

Meanwhile the "Detroit" forged slowly ahead, and, when off the starboard beam of the *Guanabara*, Commander Brownson cautioned the latter to make no mistakes and to fire no accidental shots.

While this was occurring the warping boat turned back towards the "Amy." Commander Brownson hailed the latter and told her to go in to the wharf, if she wished to do so. The master replied that he would be fired upon. Commander Brownson again told him to go ahead, that the "Detroit" would protect him. At this juncture, the "Detroit" was rounding the stern of the *Guanabara*, and the latter fired a blank charge in the direction of the "Amy;" Commander Brownson recognizing the formality of the rebel's action, a musket shot was fired from the "Detroit" which struck the *Guanabara* above her rudder post. It was then 7:36 a. m., and the "Detroit" anchored in a position to rake both the *Guanabara* and the *Trajano*.

Messages were exchanged with Admiral da Gama, whose flag was flying from the *Liberdade*. The latter called a conference of his commanding officers to decide upon further action. Pending their decision and reply, the crew of the "Detroit" remained at quarters with guns trained upon the rebel vessels. At 11:17, Admiral da Gama having acceded to the demands of Admiral Benham, the "Detroit" was directed to return to her former anchorage; she accordingly got under way, and at 11:38 rejoined the other vessels of the United States squadron, which during this time had remained under way, ready to proceed in performance of the duties assigned them had an engagement resulted.

By this time the "Amy" was moored near the dock in her new berth, and a tug came up offering to discharge without cost the cargoes of all the vessels. The latter fact was due to the mediation of Mr. Rollins, an American, and apparently the confidential agent of Admiral da Gama; at 8:18 he went on board the "San Francisco," the flagship of Admiral Benham, bearing a message from the American merchant captains, that, in consequence of being offered the use of tugs free of charge, they had changed their minds and would unload in the stream and not at the wharves. Upon the verification of this message by the flag lieutenant to Admiral Benham, notice was given to the commander of the rebel forces that the cargoes would be taken out of the vessels in the berths they then occupied, but it was still determined that if American vessels wished to have berths in the docks they would be placed there and given full protection by the squadron of the United States.

The effect of this action was to restore tranquillity, to break the attempted blockade of commerce, and to place everything in even motion in Rio de Janerio. With respect to American interests, protection was now afforded to merchant vessels of the United States, and the actual line of fire of the rebels was the only restriction to their freely receiving and discharging cargoes. Admiral da Gama withdrew his restrictive orders, and ships of all nationalities were permitted to go to the wharves.

Meanwhile, dissensions occurred in the Provisional Government at Desterro; and the cabinet minister who held the portfolios of war, inland affairs, finance, and foreign relations, resigned on account of misunderstandings with his colleagues. The rebels appear to have made no headway in perfecting the organization of their Government, nor in carrying out its purposes. At Bahia and Pernambuco their agents seem to have been on board the Government ships fitting out for service. Some harm was done in injuries to the machinery, and even in imperiling the existence of the ships. It was limited, however, by the presence of 150 military cadets distributed throughout the squadron, who gave effective support to the Americans serving in the vessels.

At daylight, on the 4th of February, the batteries on Gobernador Island opened fire on the *Aquidaban* and the *Tamandaré*, and those at Areia and Nictheroy on the armed transports in that part of the bay. Later, Armaçao began the bombardment of Cobras. At 6:45 the *Jupiter* and *Pereira da Cunha* left their anchorage in the eastern part of the bay, and on getting within range were fired on by the Gobernador and Armaçao batteries. A shell from one of the Gobernador guns struck the starboard quarter of the *Pereira da Cunha;* mats were lowered over the shot hole and the vessel anchored for repairs. The *Jupiter* continued on her course towards the city, and eventually anchored near the *Trajano*, *Guanabara*, and *Liberdade*. At 9:40 a. m. the *Aquidaban* shifted her anchorage from Engenho Island to Saude Point. While en route

she was fired at by two batteries on Gobernador Island, one at Point d'Areia, and another at the Armaçao, about 12 shots in all. None of them hit near their mark. Several fell dangerously close to the foreign shipping, one striking the water within 50 yards of the "New York's" bow, fully half a mile short of the *Aquidaban* and to the left. During the remainder of the day another transport and several armed launches joined the ships off Enxadas. This disposition of the squadron was made with a view of landing troops on the 5th, for Admiral da Gama had received promises of assistance from two regiments of the National Guard, and expected them to desert the Government as soon as his ships appeared in force in front of the city's wharves. The Government discovered the conspiracy, however, and arrested the ringleaders before the revolt could occur.

It was about this time also that the commanders of the Government warships BAHIA and TIRADENTES were arrested and superseded, and a little later the commandant of Fort Santa Cruz.

On the morning of the 9th occurred the battle of the Armação. Operations began at 3:30 by the dispatch of launches with landing parties from Conceição Island. The launches succeeded in landing their force of 500 men at Armação undiscovered; supported by the fire of the launches themselves, and by that of the *Aquidaban*, *Jupiter*, and *Liberdade*, they soon drove back the Government troops, and at 5:30 captured the battery. By this time the Government commander, reenforced by 1,000 infantry, again advanced under the fire of machine guns and riflemen on the island of Caju, which lies just opposite Point d'Areia. Another body of 100 men was brought up from Conceição, while the armed launches and the *Liberdade* stood close inshore between Mocangue Island and the mainland. The engagement now became general, and the Government forts were bombarded heavily by the squadron, aided by Forts Villegaignon and Cobras. At 8 a. m., Fort Gragaota was struck by a 9.2-inch shell from the *Aquidaban* and by two 6-inch shells from the *Tamandaré*. Between 9 and 10, Forts Villegaignon and Cobras were bombarding Fort Gragoata, and the Armação battery was also firing on it, showing that it was still in the possession of the rebels; meanwhile Fort Gragoata was engaging the *Aquidaban*, and Fort Villegaignon was under the combined fire of Santa Cruz, Lage, and São João. At 9:30 the *Liberdade*, with 4 armed tugs, emerged from Mocangue Channel and engaged the forces along the water front of Areia Point. At 10 the *Aquidaban* withdrew, having silenced Fort Gragoata and steamed towards Villegaignon, after an ineffectual attempt to make an impression upon the battery of São João Baptista. After 3 hours of hard fighting, Admiral da Gama recognized that his enemy was too strong; and spiking the guns at the Armação, which had so often annoyed his ships, he ordered his forces to embark, and at 11 o'clock, the *Liberdade* and tugs returned to their former anchorage off Saude Point, while the *Aquidaban* sought hers at Engenho

Island. The *Tamandaré* was at anchor during the attack about one-half mile west of Mocangue Island, and remained there afterwards. The rebel losses were 100 killed and wounded, and those of the Government are said to have reached 200. The attack was daring and the fighting on both sides was desperate. Admiral da Gama in person commanded the rebels, and was wounded in the neck, breast, and arm. This was the most hotly contested action of the war; and the rebels, discouraged by their repulse and failure in re-enforcement of supplies or men, from this time lost ground rapidly.

There was no firing again until the afternoon of the 11th, when the guns in São João Baptista battery opened on the *Tamandaré*. The latter was struck by three of the twelve shells that were fired; one passed completely through the ship. The *Tamandaré* thereupon moved to an anchorage west of Vianna Island and about 2.5 miles from the Baptista battery. At 9 a. m. of the 12th a shell from the latter burst on her forecastle deck. At 4:56 p. m. a gun on Gobernador Island opened fire, the second shot striking her starboard bow and three others near the water line. That night she moved to an anchorage north of Engenho Island.

On the 12th the *Aquidaban* shifted her anchorage from Engenho to Saude Point, and during the next eight days was engaged in coaling. The coal was brought from Vianna and Conceição islands. On the 19th she was struck by a shell fired from a battery at Areia Point.

At 3:45 a. m. on the 21st a rocket was fired from Fort Santa Cruz, and a few minutes later Forts Santa Cruz, Lage, São João and the Sugar Loaf batteries opened fire on the *Aquidaban*, steaming out. The latter replied with both main and secondary batteries. Her discovery was due to the search-lights on São João and Gloria Hill, the beams of which were kept trained on her till she was past the forts. This vessel joined the *Republica*, lying off the fort, and both were seen during the afternoon standing eastward. It was supposed that the two vessels would proceed northward and engage the Government fleet or else bring the much-needed re-enforcements for the squadron in Rio de Janeiro Bay.

Early on the 23d the *Pereira da Cunha*, renamed the *Venus*, lay at anchor off Tavares Island. A shell fired from a battery on Point Velha, eastward of Engenho Island, penetrated the side of the *Venus* and, bursting in the midst of some powder stored between the decks, exploded the latter, which in turn blew up the vessel. The explosion appeared to be amidships, from which section smoke and steam, with sparks and burning fragments, shot high in air. The forward end of the ship sunk first, the after end, with one smokepipe and the mizzenmast, remained awash. The officers and crew, numbering 30, were either killed or drowned. Directly after the explosion two transports lying near shifted anchorage to a position off Paqueta Island.

During these occurrences it developed that the rebels in the south were in control of the small State of Parana, except the town of Lapa,

which, strongly fortified, was defended by Col. Carneira with a force of 1,200 men. The former were poorly provided with artillery. The Government had 2,500 troops defending Itavare and about the same number at Santos, both very important strategic points as being the only natural passes from Parana into São Paulo. There was also a reserve of 2,500 at São Paulo itself. Gen. Machado was reported to have rallied his forces, numbering 4,000 men, south of the position of the rebels, and it was believed that if the latter attempted to pass into São Paulo at Itavare and were defeated, their retreat would be cut off by Machado. De Mello was reported to have abandoned his contemplated advance from Iguape to Santos.

The PIRATINY and 4 torpedo boats had reached Bahia from Pernambuco and the Government fleet was expected to arrive soon at Rio de Janeiro, where temporary accommodations for the people were erecting on the outskirts of the city, preparatory to a general engagement between the loyal and the rebel ships and forts.

A recent announcement by the Vice-President that the elections would be held on March 1 had given the people increased confidence in the Government.

On the 18th the NICTHEROY arrived and landed several hundred men at the entrance to the harbor. She then proceeded to Bahia, whence she had come. The "Santuit," an American steamer, arrived about the same time and landed a number of troops.

At the end of February the Provisional Government at Desterro had failed, and an attempt was making to organize another at Curitiba, the capital of the State of Parana. Gen. Hippolyto, in the same State, had defeated a force of 500 rebels, commanded by Gen. David, the latter losing 60 men killed and a large quantity of arms and ammunition.

The elections held on the 1st of March passed off quietly throughout the country and resulted in the overwhelming election of Dr. Prudente de Moraes as President, and Dr. Manoel Victorina Pereira as Vice-President of the Republic. Both are civilians, the newly elected President being at the time the presiding officer of the Brazilian senate, and the Vice-President elect a member of the National Congress.

More important still, from its bearing on the revolt, the Government fleet left Bahia on the evening of the 1st for Rio de Janeiro.

From this time the operations in the bay were uninteresting and unimportant until March 10. There was firing as usual, but no great damage was done. During this period it was learned in Rio that General Salquado, with 800 men, had deserted from the rebel army in Parana, and that rebels also were landing at Abatuba.

On the latter date, matters assumed a definite complexion. The Government fleet anchored in the Praia de São João, just outside the entrance to the harbor, and, on the following day, the Federal Government sent a notice to the diplomatic representatives declaring its intention of firing upon the rebels at the expiration of forty-eight hours from all the forts and batteries commanding the bay of Rio de Janeiro.

The loyal fleet consisted of the NICTHEROY, ANDRADA, PARANAHYBA, GUSTAVO SAMPAIO (late "Aurora"), SAN SALVADOR, and five first-class torpedo boats.

With the notice to the diplomats that military operations against the rebels would be resumed, the population of the capital were warned to leave the city and to seek shelter outside the range of fire. There was no doubt felt that the rebels would reply to the Government fire and bombard the city, notwithstanding the fact that, with the *Aquidaban* and the *Republica* away from Rio, and with the loyal ships guarding the entrance to the harbor to prevent their return or the escape of the hemmed-in rebel ships, they were at a great disadvantage. The dynamite cruiser NICTHEROY and the torpedo vessel SAMPAIO had taken up an advantageous and partially sheltered position under the guns of Fort São João and the Sugar Loaf batteries, while the ANDRADA, PARANAHYBA, and the torpedo boats lay outside the entrance to give warning of the approach of the enemy's absent ships and, if need be, to attack them.

Admiral da Gama evidently found himself incapable of meeting the combined attack that could be made upon him. With no appearance of a relieving force by land, and recognizing the impossibility of forcing his way out of the harbor against the fire of the forts and ships, he decided to surrender. Accordingly, on the 11th, he asked amnesty for his supporters and himself; and at 10 p. m. the commander of the Portuguese ship "Mindello" submitted to the President of Brazil in the Admiral's behalf the terms under which he offered to capitulate, and which were as follows: Actuated by a desire to terminate the bloodshed that had afflicted the country for six months and more in consequence of the war, the officers of the rebel vessels in the harbor were to lay down their arms and, under the guaranty of the Portuguese nation, were to leave the country, together with the adherents of their cause; the prisoners were to be returned, except those desirous of sharing the fate of the rebel officers, and the enlisted men or volunteers were to be guaranteed their lives.

On the same day the Admiral asked and received asylum on board the "Mindello."

The 12th was uneventful. An occasional shot was fired from the Armaçao at Cobras Island during the afternoon, and in the evening Santa Cruz shelled Villegaignon for an hour.

On the morning of the 13th it became definitely known that the terms proposed by Admiral da Gama had been declined by the Government. This reply had been anticipated, for by that time the city was practically deserted. During the preceding forty-eight hours the streets of the capital had been crowded with people flying from the city. The street cars and every available vehicle were used to assist in transporting the effects of the inhabitants seeking refuge from the threatened bombardment. In the city itself, all business houses were

closed and there was difficulty in getting food. The streets were filled with police, though the situation was fairly quiet. Almost the entire population of the central part of the city, numbering 100,000, had been conveyed to the suburbs by railway free of cost. Numbers of poor families camped on the hills outside, food being sent to them by the Government. The exodus continued until noon of the 13th.

The activity on the water corresponded to that on the land. In the early morning the usual small-arm firing occurred at Mocangué, Vianna, and Engenho islands; rebel launches passed up the harbor and a transport came down from the Paqueta anchorage, both being shelled by the Gobernador and Areia batteries, except when near the foreign ships of war or among the merchant vessels. Later, tugs and launches passed between Cobras and Vianna, evidently carrying instructions concerning the surrender; others made frequent trips under fire of the Government batteries to the "Mindello," carrying rebel refugees from Cobras and Enxadas islands and the ships near by. The Armação and Areia batteries shelled Cobras Island again and set fire to buildings on it. At noon Forts Santa Cruz, Lage, and São João bombarded Villegaignon, the latter fort replying; at 12:15 p. m. the firing ceased.

All then remained quiet until 3 o'clock, when Forts Santa Cruz, Lage, and São João, with the Sugar Loaf batteries and those at Morro do Castello, San Bento, Morro da Saude, Curvello, and in the city opened fire furiously upon Fort Villegaignon, the *Tamandaré* and the *Liberdade* (flagship of Admiral da Gama), Cobras Island, and all other vessels and islands held by the rebels. The hospital flag on Enxadas was lowered and the white pennant hoisted in its place. The Armação and Areia batteries joined in the bombardment of Villegaignon, and of Cobras Island, the attack upon the latter being very severe, and resulting in the fort being set on fire. For twenty minutes the firing was incessant from all the Government's fortified points, and at 3:35 p. m. it ceased entirely.

Meanwhile the rebel launches made frequent trips across the harbor from the rebel ships near the city front, and from Enxadas Island, loaded with men and baggage. Some went to the "Mindello" and others continued up the bay to Paqueta Island, under the full fire of the shore batteries en route till past Vianna Island.

At 4:30 Admiral da Gama went alongside the "Mindello" in a launch, having been wounded in the arm by a piece of shell during his transfer. About the same time the unconditional surrender of those who had remained on Enxadas Island, where all the rebel forces had congregated when they left Cobras, Villegaignon, and their ships, was announced.

During these happenings within the bay, the Government fleet outside kept its lookout ships in the offing until 3:45 p. m., when they, with the other ships and the torpedo boats, formed in line off Raza Island, and

steamed back and forth across the mouth of the harbor in a manner suggesting drill in fleet evolutions. At 5:30 they formed column of vessels and steamed into the harbor, the NICTHEROY leading, and followed by the SAMPAIO, ANDRADA, three torpedo boats, and the PARANAHYBA. As they passed Fort Santa Cruz, all the Government forts and batteries bombarded Fort Villegaignon, Cobras Island, and the rebel fleet. No reply was made by the rebels, who had deserted their ships and batteries and sought refuge on board the Portuguese men-of-war "Mindello" and "Albuquerque" and the merchant steamer "Cidade do Porto." The fleet continued up the harbor until abreast Villegaignon, when it changed direction to the westward, the NICTHEROY still leading and finally anchoring near the fort, the other vessels following. Two torpedo boats made a landing at Villegaignon, and the Government forces proceeded at once to occupy the abandoned ships and forts, meeting with slight resistance only, and that at the hands of a few courageous spirits who remained at one or two points to the last. Guns in celebration of the event were fired by all the forts and batteries, and displays of fireworks continued in both Rio de Janeiro and Nictheroy till a late hour at night.

The public rejoicing continued on the 14th, and during the day salutes were fired at intervals.

The "Cidade do Porto" attempted to leave the harbor with some of the rebels on board, and was stopped by the Government; the refugees, numbering about 90, were taken off.

The Government demanded from Portugal the surrrender of Admiral da Gama and the 480 refugees on board the ships of war, and the matter became a very interesting case of asylum. By consent of the Government, after the assurance of the Portuguese commander that the refugees would be held pending the settlement of the diplomatic question, the ships were allowed to go beyond the forts, to prevent infection from the yellow fever prevailing on the bay. They made their way to Montevideo; but Brazil has been firm in maintaining that the doctrine of an asylum under the conditions in this case can not be held successfully in international law.

Portugal is said to contend that it would be contrary to the principles of humanity and opposed to all precedents of international law in similar cases to comply with the demand of the Brazilian Government. At all events, the differences between the two governments have led to the severance of diplomatic relations, the Portuguese minister having recently been given his passports from the Brazilian capital.

About the 1st of May the steamer "Pedro III" was chartered at Buenos Ayres, and, convoyed by the "Alfonso de Albuquerque," left with 170 refugees on board for the port of Lisbon.

At the time of the surrender in Rio Harbor, Admiral de Mello was at Curitiba, personally directing the concentration of the rebel land forces upon the São Paulo frontier. Although the naval revolt had ended

virtually, he was acting in full sympathy with the southern rebels, and hoped to win in the end. There was still left to him the *Aquidaban*, *Republica*, *Iris*, *Meteoro*, *Urano*, *Esperança*, two torpedo boats, and two or more transports with which he might successfully combat any squadron that the Government could send against him. The rebel army was defending Ilame and Iguape. Gen. Saraiva was reported to have 3,000 men under his command, and Gen. Salgado 1,800; and in Rio Grande do Sul it was claimed that the armies were reunited, and that Gen. Tavares had 2,000 men under him, while Gen. Carada had 1,800.

Meanwhile the reorganization of the Provisional Government was completed, and Admiral de Mello became its chief. The cabinet appointed by Lorena had resigned and had been succeeded by a junta, consisting of a representative from each of the rebel States of Parana, Santa Catharina, and Rio Grande do Sul. Gen. Saraiva retained the command of the land forces; and it was probable that the captain of the *Aquidaban* would succeed to the command of the fleet.

The revolting squadron remained at Desterro, comparatively inactive till the 3rd of April, when Admiral de Mello left the island of Santa Catharina with a total force of nearly 2,500 men, including the crews of the five ships, *Republica*, *Urano*, *Meteoro*, *Esperança* and *Iris*. On the 5th the squadron crossed the bar at Rio Grande, the Government forces pouring a heavy fire upon the ships from 32-pounder Whitworth guns and 8-centimeter Krupp field pieces. On the following day the rebel forces, to the number of 2,000 men, were disembarked, and the same afternoon the Government batteries near the bar were occupied by them, the national troops retreating to the trenches thrown up for the protection of the city and situated about three miles to the southwest of it. On the 7th the Brazilian gun-vessel CANANEA opened fire upon the *Republica*, but she was soon silenced by a few well-directed shots from the latter at a distance of 3,000 yards. The gun vessel then endeavored to steam out of range, but stranded on a bank in the attempt and sank.

Meanwhile dissensions occurred on land between Gen. Salgado, commanding one division of the rebel army, and Gen. Laurentino Pinto, in command of the other. The latter officer maintained that it was impossible to take the city by assault, as it was strongly fortified and garrisoned, and that the number of their forces was insufficient to justify an attempt in that direction. During the 7th and the three following days, efforts were made to gain possession of the trenches, but unsuccessfully, the squadron bombarding at the same time such points as it could get within range. During the 10th the Government received reinforcements from Bage and Pelotas, and the rebel commanders decided to retreat. The forces were reembarked on the 11th, and the same evening the squadron put to sea. The total losses of their side were 350 killed and wounded, the Government admitting 100 killed.

On the 13th Gen. Salgado and 1,200 officers and men were landed at

Castilhos, a small village in Uruguay, about 20 miles south of the Brazilian frontier, and were granted the right of asylum by the Government of that country.

It is difficult to fix the responsibility for the failure of the attempt on Rio Grande. Gen. Salgado accused Admiral de Mello and Gen. Pinto of not supporting him in the fighting and of not aiding him in anyway, when he called on them for assistance. On the other hand, Admiral de Mello states that the fault lay with Gen. Salgado in not pushing forward to attack the city immediately after his forces were landed, on April 5. The general opinion seems to be that the attempt, at best, was a half-hearted affair.

On April 16 the *Republica*, flying the flag of Admiral de Mello, accompanied by the *Urano*, *Meteoro*, *Esperança*, and *Iris*, entered the outer roadstead of Buenos Ayres to seek protection and asylum from the Government of the Argentine Republic. Admiral de Mello at once notified the Argentine authorities that he had come to beg asylum for himself and his countrymen who were with him, and that he was ready to deliver the ships under his command to the Argentine Government if his requests were granted. It was decided immediately to give the protection asked for, and, with this decision, all further participation of Admiral de Mello in the revolt came to an end. The admiral stated that he adopted this course on account of inability to continue the contest through his lack of coal, ammunition, and provisions.

Disasters did not come singly to the rebels, for on the same day they lost the *Aquidaban*. On the 14th of April the Brazilian squadron, Rear-Admiral Gonçalvez Commander-in-Chief, consisting of the flagship ANDRADA (formerly the "America"), the NICHTHEROY, the TIRADENTES, the torpedo vessel GUSTAVO SAMPAIO (formerly the "Aurora"), and the armed merchant vessels SAN SALVADOR, ITAIPU, and SANTOS, together with the first-class torpedo boats SILVADO, PEDRO IVO, and PEDRO AFFONSO, anchored in Porto Bello Bay, several miles north of Santa Catharina Island, where nearly forty-eight hours were spent in trying to repair the machinery of the pneumatic gun on board the NICTHEROY. The ITAIPU was sent to search for the *Aquidaban*, and succeeded in discovering her at anchor in the northern entrance of Santa Catharina Strait, and about one mile south of Anhatormirim Island, on which is Fort Santa Cruz.

Admiral Gonçalvez decided to attack the *Aquidaban* at night with the torpedo boats. With this end in view the squadron proceeded to the northern entrance of Santa Catharina Strait, where it arrived about 10 o'clock on the morning of the 16th. In order to distract attention from the attack of the torpedo boats, fire was opened at once on Fort Santa Cruz, and on Fort San José, situated on Grosa Point, Santa Catharina Island.

After leaving the squadron, the torpedo boats steamed slowly south-

ward along the eastern side of the entrance until near Raton Grande Island, when they turned and proceeded northward along the western shore until the *Aquidaban* was discovered at anchor in the position reported by the *Itaipu*. The sky was clear when the torpedo boats started on their search, but before the attack was made it had become overcast and a heavy rain was falling. The commander of the GUSTAVO SAMPAIO pronounced it so dark that he was less than 200 yards from the *Aquidaban* when he discovered her. The crew of the latter were expecting a small steamer from Desterro that night, and, mistaking the SAMPAIO for her, did not fire at once.

The *Aquidaban* was heading toward the south. When first seen by the GUSTAVO SAMPAIO she bore on the starboard bow; the latter, therefore, turned to starboard to launch the bow torpedo. This, by some mistake of the officer in charge of it, was fired before the vessel was in position and without effect. The SAMPAIO then backed, and turning under the stern of the *Aquidaban* steamed slowly along the port side, probably not more than 20 yards from her. In this remarkable position, however, it was not until the SAMPAIO was nearly past the battle ship that the starboard after torpedo was fired; it struck with terrific effect about 20 feet abaft the stem of the *Aquidaban*, lifting the bow considerably out of the water. The SAMPAIO then dashed ahead at full speed to rejoin the squadron.

Before the first torpedo was launched the *Aquidaban* opened fire on the SAMPAIO and her consorts from the Nordenfeldts and two of the 5.7-inch guns. The SAMPAIO was hit thirty-five times in the upper works and three in the hull by Nordenfeldt 1-inch steel projectiles. One of them penetrated the starboard bow near the water line, damaging the distiller. Two of them struck a Hotchkiss rapid-firing 3-pounder, one hitting the breech square and jamming the breechblock slightly, while the other penetrated the wall of the gun directly over the cartridge chamber to the depth of an inch, or three-fourths of its thickness, but without injury to the bore, so that it could still be fired. Excepting a cadet who lost a finger, no one on board the SAMPAIO was hurt. Her escape was due to the darkness of the night, coupled with such proximity to the battleship that the latter's projectiles went over her.

The PEDRO AFFONSO launched two of her torpedoes. The breakage of a pipe connected with the air compressor prevented the firing of the bow tube, so that both these torpedoes were launched from the after deck.

The SILVADO was about to fire a torpedo when her commander discovered that the SAMPAIO was between his boat and the battleship.

As a matter of technical interest, it is proper to remark that the PEDRO IVO left the squadron with the flotilla, but being unable to maintain sufficient steam pressure fell out of line and took refuge under the guns of the TIRADENTES.

The PEDRO AFFONSO, SILVADO, and PEDRO IVO are three of the five

first-class Schichau torpedo boats delivered to the Brazilian Government at Pernambuco. One of these was sunk at sea on the way south by a collision with the SAMPAIO; another was lost on the coast of Brazil; and only two finally took part in the attack on the *Aquidaban*. Neither of them was hit by the latter's projectiles.

The torpedo fired by the SAMPAIO was of the Schwartzkopf type, and contained a gun-cotton charge weighing 125 pounds. When this vessel was turned over to the Brazilian navy she had but one launching tube, and that in her bow; before leaving Rio de Janeiro two broadside Whitehead tubes were transferred to her from the TIRADENTES. The changes needed to adapt them to the Schwartzkopf torpedo were made successfully.

The attack on the *Aquidaban* was not renewed until the next day, when it was discovered that she had been abandoned by her crew, who had escaped to the mainland. Deserted by their officers, 80 of them a few days later gave themselves up to the Government ships. The big battle ship, drawing 20 feet aft, was found in 24 feet of water with the two forward compartments full of water.

She is said to have made the trip from her anchorage to Rio de Janeiro with her own engines, with two forward compartments full of water, and is now undergoing repairs in the Government dry dock.

The illustration of the ship in dock shows the effect of the SAMPAIO'S torpedo on the port bow.

The *Aquidaban* was struck between the sixth and seventh frames, the injuries extending from the bow to the twelfth frame, and below the protective deck, which was apparently uninjured. All plates, frames, etc., on this side were crushed inward, denoting an external explosion; the water-tight bulkhead at the sixth frame was entirely carried away, as were other frames aft to the water-tight bulkhead at the twelfth, which stood intact with doors closed, and only two forward compartments were flooded.

On the starboard bow, about two feet above the keel and near frame seven, was a hole about two feet in diameter, the ragged edges of which are flanged outward and aft; the frames, longitudinals, and plating are much twisted and curled, but the remainder of the hull is in good condition.

When the garrisons of Forts San Jose and Santa Cruz and the officials at Desterro saw the disaster that had befallen the *Aquidaban*, they escaped to the mainland, and the island of Santa Catharina with its capital was occupied by the Government troops without further resistance.

The naval revolt crushed, the Brazilian Government had to deal only with the army under Gen. Saraiva and other rebels in various parts of the State of Rio Grande do Sul. Press accounts in April report Gen. Saraiva entering the northwest corner of Rio Grande and marching southward to join forces with Gen. Tavares. During the same month, an

emissary from Dr. Prudente de Moraes, the President elect, approached Dr. Silveira Martins on the subject of a compromise to restore peace in the south. The latter expressed himself willing to undertake the pacification of Rio Grande, but demanded that all officers should be reinstated in the grades they held before the revolt broke out; that a free election should be held throughout Brazil; and that Senhor Castilhos, the governor of Rio Grande, should be recalled and a free pardon granted to all political offenders. These terms were not accepted. Brazil had already offered amnesty to the refugee soldiers and sailors at Montevideo and Buenos Ayres, but did not extend it to the rebel officers. Of the former, 270 by May had expressed their intention of accepting the offer and returning to Rio de Janeiro.

The Government has continued operations against the rebels, pressing them closely, and with varying success. Reports sent abroad by sympathizers with the latter announce, on June 26, that Gen. Saraiva was attacking the city of Rio Grande, and that Gen. Tigre, with 850 men and 4 guns, had arrived at Itacarucu, on the upper Parana, and had taken possession of Iguarzu, a military colony of which he had proclaimed himself governor. Advices of the following day state that national troops had defeated the rear guard of Gen. Tigre's army and captured its artillery and other munitions of war. Government reports of the same date proclaim that Gen. Saraiva had been attacked and his force dispersed, and, denying the story of Gen. Tigre's success, confirm the defeat of a part of his force, and assert that with his remaining troops he had crossed into the Argentine part of the Missiones Territory and had sought refuge there.

The organization of the rebel forces was practically that of the Brazilian Navy prior to the revolt. Although there was a provisional government at Santa Catharina, yet the administration seemed personal, the officers and men yielding their allegiance to Admirals de Mello and da Gama as chiefs.

When Admiral da Gama issued his first manifesto, it was rumored that he did so with the understanding that Admiral de Mello would leave Rio de Janeiro.

The discipline of the rebels was good, apparently, and their courage and bravery admitted of no question.

The ships generally fought at long range, the commanders seeming to be husbanding their resources from the outset. The *Aquidaban* had a crew sufficient for fighting her battery in the early part of the revolt, but the other ships were undermanned. The transports rarely had a complement exceeding 35 men, and at one time there were only 37 on board the *Almirante Tamandaré*, a vessel of 4,500 tons displacement. These facts probably account very much for the minor parts taken by the ships in such actions as those of the Armação, as compared with those usual for vessels of such size when fully manned and supplied

with ammunition. The policy of the rebels, in fact, seemed a waiting one; their operations sometimes impressed a spectator as initial steps toward an end, to be further developed or extended on the arrival of reinforcements from the south.

The armed tugs and launches did good service. They were very active and efficient at night, transporting men and material, and, during the day, did much fighting. Armed with revolving cannon and rapid-firing guns, barricaded by cotton bales or boiler iron, behind which were armed crews, they were ugly antagonists. Their work in Rio harbor showed that, under the practical conditions of nearly any war, such port resources could be well utilized as auxiliaries in the defense of a harbor, river, or bay.

The torpedo boat near the *Aquidaban* that was struck and sunk by a shell from Santa Cruz on the 8th of November was 6,000 yards distant from the fort. When hit it was alongside the battle ship; it shoved off immediately, and was taken in charge by two tugs, but began to settle before 100 yards away. The smoke pipe went out of sight, and the stern rose gradually, till the boat seemed to stand directly on end in the water; it then disappeared slowly, sinking vertically. Some observers believe that this boat was sunk by a shell from Fort Gragoata or São João Baptista.

In many instances, field pieces were moved from point to point on the shore line and used against the rebel ships.

Smokeless powder was used on board the *Tamandaré* only. Upon the discharge of one of her 6-inch guns, a small yellowish red cloud of smoke was seen for a few moments; it dissipated quickly, and at no time would it have interfered with her firing. Great was the contrast when one of the *Aquidaban's* turret guns was fired; a thick heavy cloud of smoke that almost enveloped the ship was the invariable result, drifting slowly away unless a strong breeze was blowing.

Nictheroy was the key to the situation. The aim of the rebels was to capture it, and thereby cut off Fort Santa Cruz from Government aid by land. The fort could then be captured by the attack of a landing force coupled with the fire of the ships and Villegaignon. This done, Forts Lage and São João would fall of necessity, and the blockade of Rio de Janeiro would be established.

With the *Aquidaban* in port, the Government policy was to cut off supplies from the rebels and to harass their ships with artillery fire from the forts and batteries. The balance of force was with the troops on land, but they were much scattered on account of the long shore line to be defended and the need for a strong garrison in Nictheroy. The failure of the Government to make more serious attempts to storm Villegaignon and Cobras Island is due, probably, to the fact that both forts were strongly defended, and the troops would have to approach in boats, exposed to heavy fire from great guns, rapid-firing and machine guns, and small arms.

If the reported expenditure of ammunition be correct, it is worthy of comment that the great guns did not give out, for most of them fired ten to fifteen times as many rounds as is generally conceded to be the life of heavy artillery. Most of the batteries fired almost continuously at long ranges and with extreme elevation, and at the close of the revolt, after six months' use, did fair shooting. The best firing in the harbor was done by the 6-inch guns of the *Tamandaré*, using a 17-pound charge of cordite. Several accidents occurred on board, however, due almost entirely to carelessness; the ship being undermanned, a supply of ammunition for the work intended was generally brought on deck to avoid delay. On three occasions shells from the shore batteries burst close to the supply of cartridges and exploded them, causing the death of two officers and wounding a dozen men.

Generally speaking the firing throughout was ill-directed. The larger proportion of the shots from both sides fell short. This was attributed by many observers to the bad or varying quality of the powder used, rather than to the inefficiency of the gunners. Sometimes the marksmanship at ranges of even two to four miles was excellent, and again extremely poor. The Areia batteries were less than one mile from the coal piles on Vianna and Conceição islands; every tug and lighter approaching or leaving these islands, or passing from the northeastern part of the bay to the ships near Saude Point, was fired on, but the only known casualty was the sinking of the launch in Mocangué Channel during the last days of February. The firing was so wild, in fact, that the rebel vessels seemed reckless; they made no attempts to keep out of range, and steamed, even with lighters in tow, direct to their destination, the shells falling either one-fourth of a mile beyond them or as much short.

It is stated that when the *Tamandaré* fell into the hands of the rebels her 6-inch guns were found without sights, and that wooden ones were then fitted to them. During the course of the war this vessel was damaged badly about the upper works and by plunging fire through the decks. There was no serious injury about the water line. The decks could not be washed down on account of the shot-holes through them.

In February the port side of the *Aquidaban* showed that she had been hit many times, but with the exception of a bent port shutter there was no evidence of injury. The indentations that were visible seemed to have been made by small projectiles. An authentic report states that during an action between the ships and the forts on the 30th of September, this vessel was hit five times. A 6-inch shell passed through the deck into the admiral's cabin and burst there; bulkheads were destroyed, but no fire resulted. A 6-inch solid shot penetrated the starboard side and hit a 6-inch shell standing in a rack on the gun deck; the shell, which was fused, exploded, wounding one officer and three men. A third shell penetrated the starboard side and,

without bursting, destroyed the fittings of the admiral's bathroom. Another penetrated the port side amidships and burst in a port coal-bunker; the projectile made a hole in the ship's plating of the same circumference as itself; it also struck the inner bulkhead of the coal-bunker, tearing two irregular holes through which fragments passed and wounded an enlisted man. The fifth projectile, a solid shot, struck the shield of the port bow gun without injuring it enough to prevent the working of the weapon. In addition, several solid shots struck the armored portions of the hull, leaving only slight indentations.

Of two observers on board a foreign warship who saw the *Javary* sink, one thought that the shell from Fort São João fell very close to her side, and the other that it hit her forward deck.

Search lights were operated nightly. The range of the one on Gloria Hill was limited by the contour of the port. It was a noticeable fact that, when its beam was projected across the harbor, objects on the opposite side of the beam from the observer were not visible. From this it may be inferred that when the arc of a search light is limited by physical conditions, torpedo boats especially may approach the limits of its zone with comparatively small risk of discovery, and may accomplish thereby a successful attack upon an enemy's ships.

Nictheroy, after months of bombardment, presented on all sides dismantled houses, roofless walls, streets choked with débris, remains of buildings black with soot and smoke or peppered with bullet marks. A similar state of things existed in other exposed parts of the bay.

At Fort Villegaignon the officers' quarters, guardrooms, and barracks were in ruins. Along the lower casemates in the small angle covering the Praia Flamingo and the upper bay, there remained uninjured about 20 small breech-loading Whitworth and Nordenfeldt guns sheltered by sandbags, and commanding the war arsenal on the Rio front. The lower part of the fort has the general outline of a triangle. In the corner facing São João and Lage is a deep pit lined with solid masonry. Here was mounted an 8-inch M. L. Armstrong rifle on a Moncrieff disappearing carriage. One morning in February a 450-pound shot from São João hit this gun directly in the muzzle, splitting the outer tube, shattering the carriage, and hurling the gun, breech downward, into the pit.

After the destruction of their barracks, the men stationed at the lower tier of guns had no sleeping quarters. To secure rest, holes from four to six feet deep were dug in the ground alongside of each gun, and then arched over with timbers from the débris and covered with sand and cotton bales. Entrance was gained by a small hole, just large enough to admit one man.

On the north side, the bridge across the fosse had been destroyed; and here were evidences of the mines that were to be fired if the loyal troops had gained a landing. Electrical wires led to the wharf, into the fosse, and to other points of vantage; they were now cut, but gun

cotton and dynamite had been found ready for explosion by an electric battery near the doorway of the fort. On either side of the passageway from the latter were solid shot, shell, and cannister. The vertical thickness of the solid masonry, brick lining, and concrete covering between the top of the passageway and the level above is fully 15 feet. Another solid shot of 450 pounds weight from Fort São João penetrated this thickness and lodged in the passageway. On the incline leading to the upper works were 8 and 10-inch Armstrong muzzle-loaders, chipped and battered, with carriages on end, overturned, or utterly destroyed.

The north wall of a square building in the center of the fort was in ruins, having been demolished by the guns of Fort Gragoata. The sea face was in ruins from the bombardment of Santa Cruz, Lage, São João, and the Sugar Loaf batteries.

Fort Lage was much damaged on its southwestern face, as shown by its crumbled parapets. Marks of shells from Villegaignon and the *Aquidaban* were visible on the western face of Fort Santa Cruz, but, in the main, the damages were slight.

The *Aquidaban*, as Admiral de Mello's flagship, was from the outbreak of hostilities to the end of the revolt the head center of the operations. In the fighting in Rio Bay, she bore the principal share, now dropping her shells among the enemy's positions on shore, now serving as a target for every gun that could be brought to bear on her, and with but little harm to the ship. Three times she ran successfully the Government forts at the month of Rio harbor. She passed out and in practically unscathed, despite the search lights of the forts and the heavy cannonade. And perhaps the chief lesson of value developed by this war is the fact that the *Aquidaban* was the strength of the revolt. Without her, the rebels would have been crushed in a short time; for, considering the number of guns at hand and the land forces available at that time, no excuse could be offered by the Government forces for not capturing the islands and driving the ships from the harbor or else forcing them to surrender. The lesson is most important as demonstrating the great value of battleships in attack upon a coast and their reciprocal value in defense. Her movements and operations were constantly before the Brazilian Government and people as the most important of all. Every one felt that, if she were destroyed, short work would be made of the other revolting forces. That she did not try conclusions with the Brazilian fleet on its way south was probably due to lack of men, coal, and ammunition. Her central and commanding position emphasizes the conclusion already reached by some leading tacticians that battleships will be the principal units in attack or defense, and that without a sufficient number of them no adequate defense or line of battle can be presented against a hostile and modern fleet. For more than six months this one battleship practically held at bay the city and harbor of Rio de Janeiro, despite the numerous well-armed forts and batteries.

BRAZIL
SCALE
Geographical Miles 60 = 1 Degree
COLOMBIA
BOGOTA
ECUADOR
PERU
LIMA
BOLIVIA
SUCRE
POTOSI
COCHABAMBA
SANTA CRUZ
CORUMBA
PARAGUAY
URUGUAY
VALPARAISO
BRITISH
DUTCH
FRENCH
AMAZONAS
SAN MARTIN
BOUNDARY IN DISPUTE
TABATINGA
IQUITOS
Amazon
MARAJO
PARA
BRAGANZA
MARANHAO
CEARA
FORTALEZA
RIO GRANDE DO NORTE
NATAL
PARAHIBA
PERNAMBUCO
SERGIPE
BAHIA
Todos os Santos Bay
MATTO GROSSO
GOYAZ
MINAS GERAES
CARAVELLAS
CAMPOS
RIO DE JANEIRO
SAO PAULO
SANTOS
PARANA
PARANAGUA
S. CATHARINA
DESTERRO
LOBOS
RIO GRANDE DO SUL
PORTO ALEGRE
RIO GRANDE DO SUL
CORRIENTES
ENTRE RIOS
SANTA FE
CORDOVA
SANTIAGO DEL ESTERO
CATAMARCA
RIOJA
SAN JUAN
MENDOZA
SAN LUIS
TUCUMAN
JUJUY
LA PLATA
COLONIA
S. MATIAS
MOLLENDO
PISAGUA
IQUIQUE
ANTOFAGASTA
CALDERA
CHAÑARAL

BAY OF RIO JANEIRO
COPIED FROM H O CHART NO 971
SEARCH LIGHTS
TO ACCOMPANY INTELIGENCE REPORT
FROM
U S S. SAN FRANCISCO
MARCH 31. 1894
A. W. Grant
Lieutenant U.S. Navy.
Intelligence Officer.
I. DO GOVERNADOR
3FM. CURVE
BROCOIO I
PAQUETA I
BOQUEIRAOL I.
NHANQUETA I
TABACI I.
VIRAPONGA I
RIJO I.
PALMAS I
TAPUAMOS
N.S. DA LUZ
JURUBAHYBAS IS
CONMIDA
REDONDA
TAPUTEIA I
RIBEIRA PT.
TAVARES
P. DE S. GONCALO
ENGENHO
AQUIDABAN
TAMANDARE
P. DO VELHO
MATOZO PT.
SESCA I
3FM. CURVE
ANCHORAGE
FOR
FOREIGN
MERCHANT VESSELS MEN OF WAR.
ANANAS I
AJUDANTE I
CAQUEIRADA I
OR
BOM JESUS I
VELHA I
P. BARRETO
PEDRO
VIANNA I
COAL I
CEMETERY BATTERY
MUCANGUE
CONCEICAO I
AREIA
ARMACAO
ERREIROS I
LIBERDADE
CAJU PT.
GUANABARA
TRAJANO
ENCHADAS
S. BARBARA
S. LOURENCO
NICTHEROY
I DAS COBRAS.
SAUDE PT.
RAT I.
FT SAO JOAO BAPTISTA.
FT GRAGOATA
PALACIO DA
BOA VISTA
RIO DE
JANEIRO
VILLEGAGNON FT.
S. THERESA CONVENT
JUROJUBA PT.
GLORIA
HILL
ACQUEDUCT
FORT LAGE
FT PICO
FT. SANTA CRUZ
VIUVA
HILL
TIJUCA
3316
BOTOFOGO
SUGAR LOAF
CORCOVADO
2272
MILITARY
SCHOOL
SEMAPHORE
COTUNDUBA I.
CONVENT
MENINO
MAI I
N.S DA
COPA CABANA
PAI I
GAVIA
2575
NAUTICAL MILES
1 12 11 10 0 1 2 3 4 5 6 7 8 9 10

XI.

SOME STANDARD BOOKS ON PROFESSIONAL SUBJECTS.

Officers and others are requested to inform the Office of Naval Intelligence of any standard works on professional subjects, of recent date, which are not mentioned in the following list:

Foreign books, newspapers, and periodicals may be obtained from B. F. Stevens, 4 Trafalgar Square, Charing Cross, London. From B. F. Stevens' advertising circular "new books are charged at trade prices, which are usually 25 per cent off the price of publication." "Book postage to America is only one-half penny for every 2 ounces up to 4 pounds weight."

"The discount off publication price is about equivalent to the cost of freight or postage, and commission; hence, in making purchases of new books it is safe to estimate that the books would be received at a cost of 25 cents to the shilling (publication price), exclusive of duty, if any."

Remittances to B. F. Stevens, 4 Trafalgar Square, Charing Cross, London, may be made in sterling by banker's drafts, or post-office orders on London, or in American currency at $5 to the pound sterling, this being 25 cents to the shilling. For odd amounts send postage stamps. New York agents, Tice & Lynch, 45 William street.

ARMOR.

Development of Armor for Naval Use. 1883. By Lieut. E. W. Very, U. S. Navy. Published in proceedings of U. S. Naval Institute, Vol. IX, No. 3; whole No. 25. Can be purchased of the secretary of the U. S. Naval Institute, Annapolis, Md. Price, $1.

The above work and Chapter VI of General Information Series, No. X, by Lieut. Southerland, U. S. Navy, and Chapter VI of General Information Series, No. XI, by Ensign Simpson, U. S. Navy, contain a complete history of the development of armor.

The Present Position of British and Foreign Armor. 1891. By Capt. C. Orde Browne, late R. A. (Lecturer on Armor to the Royal Artillery College). Price, 1*s*. Published in the United Service Magazine, February, 1891. Page 464 *et seq*. Offices of Magazine, 15 York street, Covent Garden, W. C., London.

Notes on Armor and Armor Trials are contained in the General Information Series of the Office of Naval Intelligence, beginning with the year 1886 and continuing in successive numbers.

GENERAL INFORMATION SERIES—

No. V, 1886, page 239 *et seq.* Edition exhausted.

No. VI, 1887, page 322 *et seq.* Edition exhausted.

No. VII, 1888, page 380 *et seq.* Armor and Armor-Piercing Projectiles. Edition exhausted.

No. VIII, 1889, Distribution of Armor, pages 81 to 135, gives a graphic history of armor protection and distribution on war vessels. Pages 424 to 427, Notes on Armor. Edition exhausted.

No. IX, 1890, page 132 *et seq.* Armor and armor protection. Edition exhausted.

No. X, Chapter VI. The Armor question in 1891. Edition exhausted.

No. XI, Chapter VI.

These numbers have been furnished to ships' libraries as well as to the officers of the Navy.

COMPASSES.

PRACTICAL PROBLEMS AND THE COMPENSATION OF THE COMPASS IN THE U. S. NAVY. 1892. By Lieut. S. W. B. Diehl, U. S. Navy. Navy Department, Bureau of Equipment.

ADMIRALTY MANUAL FOR THE DEVIATIONS OF THE COMPASS. 1882. By F. J. Evans, R. N., F. R. S., superintendent of the Compass Department of the Admiralty, and Archibald Smith, M. A., F. R. S., late Fellow of Trinity College, Cambridge. Price, $1.60. May be obtained from storekeeper at Naval Academy. Published by order of the Lords Commissioners of the Admiralty. London, 1882. Sold by J. D. Potter, 31 Poultry and 11 King street, Tower Hill. Price, 4*s.* 6*d.* Supplied to U. S. ships' libraries. Text-book at Naval Academy. Fifth edition.

ELEMENTARY MANUAL FOR THE DEVIATIONS OF THE COMPASS IN IRON SHIPS. 1889. By F. J. Evans, K. C. B., F. R. S., Captain, R. N. Seventh edition. Price, $1.68. May be obtained from storekeeper at Naval Academy. Text-book at Naval Academy. Published by J. D. Porter, London, 1889, 31 Poultry and 11 King street, Tower Hill. Price, $1. Arranged in a series of questions and answers, intended for the use of seamen, adjusters of compasses, and navigation schools, and as an introduction and companion to the Admiralty Manual for the Deviations of the Compass. Revised and with an appendix by E. W. Creak, Staff Commander, R. N., F. R. S. Supplied to U. S. ships' libraries.

THE MATHEMATICAL THEORY OF THE DEVIATIONS OF THE COMPASS. 1879. By J. A. Howell, Commander, U. S. Navy. Printed by the Government Printing Office, Washington, D. C. Arranged for the use of the cadets at the U. S. Naval Academy. Supplied to U. S. ships' libraries.

CHRONOMETERS.

NOTES ON THE MANAGEMENT OF CHRONOMETERS AND THE MEASUREMENT OF MERIDIAN DISTANCES. By Charles F. N. Shadwell, esq., C. B., Captain R. N. Price, 5*s.* New edition, carefully revised. London: J. D. Potter, 31 Poultry and 11 King street, Tower Hill.

LA MARCHE ET LA CONDUITE DES CHRONOMETRES, APRES LES TRAVEAUX DE MM. CASPARI LIEUSSOU, DE MAGNÆ, ETC. 1882. Par Fulgence Legal, Lieutenant de caisseau. Price, 1 franc 50 centimes. Paris: Berger-Levrault et Cie., 5 Rue des Beaux-Arts.

ELECTRICITY AND MAGNETISM.

THE PRACTICAL MANAGEMENT OF DYNAMOS AND MOTORS. By Crocker and Wheeler. 1894. D. Van Nostrand & Co., New York. Price, $1.

ELECTRIC TRANSFORMATION OF POWER. By Atkinson. 1893. D. Van Nostrand & Co., New York. Price, $2.

AMERICAN TELEGRAPHY. By Wm. Maver, jr. 1892. D. Van Nostrand & Co., New York. Price, $3.50.

DYNAMO TENDERS' HAND-BOOK. 1893. By F. B. Badt, late First Lieutenant Royal Prussian Artillery. 70 illustrations. Fifth edition. Chicago, Illinois: Electrician Publishing Company.

ELECTRIC TRANSMISSION HAND-BOOK. 1891. By F. B. Badt. 22 illustrations and 27 tables. Chicago, Illinois: Electrician Publishing Company.

INCANDESCENT WIRING HAND-BOOK. 1892. By F. B. Badt. 42 illustrations and 5 tables. Third edition. Chicago, Illinois: Electrician Publishing Company.

BELL HANGERS' HAND-BOOK. 1892. By F. B. Badt. 97 illustrations. Third edition. Chicago, Illinois: Electrician Publishing Company.

PRACTICAL ELECTRICITY. 1889. By W. E. Ayrton, F. R. S., associate member of the Institution of Civil Engineers; Professor of Applied Physics at the City and Guilds of London Central Institution. Price, $2.50. Cassel & Company, Limited, London, Paris, New York, and Melbourne. Also by W. J. Johnston Company, Times Building, New York. A laboratory and lecture course for first-year students of electrical engineering, based on the practical definitions of the electrical units. With numerous illustrations. Fourth edition.

DYNAMO-ELECTRICAL MACHINERY. 1888. By Silvanus B. Thompson, D. Sc., B. A., Principal of and Professor of Physics in the City and Guilds of London Technical College, Finsbury; late professor of experimental physics in University College, Bristol; member of the Society of Telegraph Engineers and Electricians; member of the Physical Society of London; membre de la Société de Physique de Paris; honorary member of the Physical Society of Frankfort-on-the-Main; fellow of the Royal Astronomical Society. Price, 12*s.* 6*d.* E. & F. N. Spon, 125 Strand, London; 12 Cortlandt street, New York. Griffin & Co., 2 The Hard, Portsmouth, England. A manual for students of electro-technics. Third edition, enlarged and revised.

ELEMENTARY MANUAL OF MAGNETISM AND ELECTRICITY. 1889 and 1890. By Andrew Jamieson, M. Inst. C. E.; professor of engineering, The Glasgow and West of Scotland Technical College, etc. Charles Griffin & Co., Exeter street, Strand, London. Part I, Magnetism. Part II, Voltaic electricity, electro-magnetism, and electro-kinetics. Part III, Electrostatics or frictional electricity. Numerous illustrated experiments. Specially arranged for the use of first-year science and art department and other electrical students.

ELECTROMOTERS, HOW MADE AND HOW USED. By S. R. Bottone. Price, $1.20. New York: D. Van Nostrand & Co. A handbook for amateurs and practical men.

REPRINT OF PAPERS ON ELECTROSTATICS AND MAGNETISM. 1884. By Sir William Thompson, D. C. L., Professor of Natural Philosophy at the University at Glasgow. London: Macmillan & Co. Second edition.

ELECTRICITY IN THEORY AND PRACTICE, OR THE ELEMENTS OF ELECTRICAL ENGINEERING. By Lieut. Bradley A. Fiske, U. S. Navy. Price, $2.50. The W. J. Johnston Co., Limited, 167–177 Times Building, New York. Also by D. Van Nostrand, 23 Murray street and 27 Warren street, New York. Griffin and Co., 2 The Hard, Portsmouth, England. Price, 10*s.* Cloth. 270 pages, 180 illustrations.

L'ÉLECTRICITÉ APPLIQUÉE À L'ART MILITAIRE. 1889. Par le Colonel Gun. Price, 3 francs 50 centimes. Paris, librairie J.-B. Baillière et fils, rue Hautefeuille, 19, près du boulevard Saint-Germain. Avec 140 figures dans le texte.

L'ÉCLAIRAGE ÉLECTRIQUE À LA GUERRE. 1889. Par Rodolphe Van Wetter, Lieutenant d'ertillerie de l'armée Belge. Prix, 7 francs 50 centimes. Paris, G. Carre, libraire-éditeur, rue Saint André des Arts, 58. Madrid, Fuentes y

Capdeville, 7 Plaza de Santa Anna. Rome, Turin, Florence, H. Loescher, libraire-éditeur. Gravures dans le texte et atlas de dix-sept planches.

ÉLECTRICITÉ EXPÉRIMENTALE ET PRATIQUE, 1889 and 1890. Par H. Leblond, agrégé des sciences physiques (Bibliothèque du marin). Price, 26 francs. Published by Berger-Levrault et Cie, 5, rue des Beaux-Arts, Paris. 3 volumes in-8° avec figures et planches, broché, chacun à 6 francs.

Vol. I. Études générales des phénomènes électriques et des lois qui les regissent, 1889.

Vol. II. Mesures électriques, 1889.

Vol. III. 1er fascicule: Description et emploi du matériel électrique de la marine, 1890. 2e fascicule, idem, 1891. 8 francs.

Cours professé à École des torpilleurs.

LEÇONS SUR L'ÉLECTRICITÉ, 1890. Gérard (Eric), directeur de l'Institut électrotechnique Montefiore. Price, 20 francs. Published by Gauthier-Villars et fils, 55, Quai des Grands-Augustins, Paris.

Deux volumes grand in-8, se vendent séparément:

Tome I. Théorie de l'électricité et du magnétisme. Électrométrie. Théorie et construction des générateurs et des transformateurs électriques. Grand in-8, avec 246 figures dans le texte. 1890. Prix, 12 francs.

Tome II. Canalisation et distribution de l'énergie électrique. Applications de l'électricité à la production et à la transmission de la puissance motrice, à la traction, à l'éclairage et à la métallurgie. Grand in-8, avec 42 figures dans le texte. 1890. Prix, 8 francs. Professées à l'Institut Électrotechnique Montefiore, annexé à l'Université de Liège.

The following works, published and for sale by The W. J. Johnston Company, Limited, 167–177 Times Building, New York:

ELECTRICITY TREATED EXPERIMENTALLY. By Cumming. Cloth, $1.50. 389 pages. 242 illustrations. For the use of schools and students.

INTRODUCTORY TO THE THEORY OF ELECTRICITY. By Cumming. Price, $2.25. With numerous examples. Cloth. 326 pages. 100 illustrations.

ALTERNATING CURRENTS. By Bedell and Crehore. 1893. Price, $2.50. 300 pages. 112 illustrations. An analytical and graphical treatment for students and engineers.

ELECTRICITY FOR ENGINEERS. By Desmond. Price, $2.50. 424 pages. 131 illustrations. Treatise on the principles, construction, and operation of dynamos, motors, lamps, indicators, and measuring instruments, and the different systems of arc lighting.

SHORT LECTURES TO ELECTRICAL ARTISANS. By Flemming. Price, $1.50. A course of experimental lectures delivered to a practical audience. 206 pages. 74 illustrations.

ELECTRICITY AND MAGNETISM, WITH AN APPENDIX ON THE TELEPHONE AND MICROPHONE. By Jenkin. Price, $1.50. Cloth. 391 pages. 177 illustrations.

A TREATISE ON ELECTRICITY AND MAGNETISM. 1883. By Mascart and Jubert. Translated by E. Atkinson, Ph. D., F. C. S. Price, $14.90. London publishers, Thomas de la Rue & Co., 110 Bunhill Row. Textbook, Johns Hopkins University. 2 vols., sold separately. Vol. I, General phenomena and theory. Cloth, 654 pages. 127 illustrations. Price, $7.40. Vol. II, Methods of measurement and application. Cloth. 792 pages. 136 illustrations. Price, $7.50.

TREATISE ON ELECTRICITY AND MAGNETISM. By Maxwell. Price, $8. 2 vols. 20 plates. 105 illustrations. Second edition.

AN ELEMENTARY TREATISE ON ELECTRICITY. 1881. By Maxwell. Edited by William Garmet, M. A. Price, $1.90. Oxford: Clarendon Press. Cloth. 208 pages. 6 plates. 54 illustrations.

NOTES ON ELECTRICITY AND MAGNETISM. 1881. By J. B. Murdock. Price, 60 cents. Also published by Macmillan & Co., New York (Proceedings of U. S. Naval Institute). Designed as a companion to S. P. Thompson's Elementary Lessons. Cloth. 139 pages. 38 illustrations.

LESSONS IN ELEMENTARY PRACTICAL PHYSICS, ELECTRICITY, AND MAGNETISM. By Stewart and Gee. Price, $2.25. Cloth. 497 pages. 223 illustrations.

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ABSOLUTE MEASUREMENTS IN ELECTRICITY AND MAGNETISM. By Gray. Price, $1.25. Also published by Macmillan & Co., New York and London. 1889. Second edition, revised and greatly enlarged. Cloth. 384 pages. 66 illustrations.

A HANDBOOK OF ELECTRICAL TESTING. By Kempe. Price, $5. Also published by E. & F. N. Spon, 16 Charing Cross, London: 35 Murray street, New York. Griffin & Co., 2 The Hard, Portsmouth, England. 15*s*. Third edition. Cloth. 551 pages. 159 illustrations.

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TRAITÉ THÉORIQUE ET PRATIQUE DES EXPLOSIFS MODERNES ET DICTIONNAIRE DES POUDRES ET EXPLOSIFS. 1889. By Paul F. Chalon, ingénieur des arts et manufactures. Price, 25 francs. Publishers, E. Bernard et Cie, 71, rue La Condamine; 53, Quai des Grands-Augustins. 1 vol. in-8 de 506 pp., avec 162 fig. dans le texte. Seconde édition.

SUBMARINE MINES AND TORPEDOES AS APPLIED TO HARBOR DEFENSE. 1889. By John Townsend Bucknil, London, Offices of Engineering, 35 and 36 Bedford street. [See under Submarine mines.] Chapter VI of this work, under the title of Examination of the Different Explosives, gives short descriptions of the principal ones as far as known up to date, 1889, their composition, intensity, advantages for submarine mines, etc.

A HANDBOOK ON MODERN EXPLOSIVES. 1890. By M. Eissler, mining engineer and metallurgical chemist, author of Modern High Explosives, etc. Published by Crosby Lockwood & Son, 7 Stationers' Hall Court, Ludgate Hill. This is a practical treatise on the manufacture and application of dynamite, gun cotton, nitroglycerine, and other explosive compounds, including the manufacture of collodion cotton.

HIGH EXPLOSIVES IN WARFARE. 1891. By Commander F. M. Barber, U. S. Navy. Published in the Journal of the Franklin Institute, Vol. CXXXI, No. 782, February, 1891, No. 2, pages 117 *et seq.*, Philadelphia. Dr. Wm. H. Wahl, secretary

of the institute. A lecture delivered November 28, 1890, before the Franklin Institute.

PROFESSIONAL PAPERS OF THE CORPS OF ENGINEERS, U. S. ARMY. No. 23. REPORT UPON EXPERIMENTS AND INVESTIGATION TO DEVELOP A SYSTEM OF SUBMARINE MINES FOR DEFENDING HARBORS OF THE UNITED STATES. 1881. Submitted to the Board of Engineers by Lieut. Col. Henry L. Abbott, Corps of Engineers, Brevet Brigadier-General, U. S. Army, member of the board. Washington, Government Printing Office.

A DICTIONARY OF EXPLOSIVES. 1889. By Maj. J. P. Cundill, Royal Artillery. Printed by W. & J. Mackay & Co., Chatham. Published by the Royal Engineers' Institute, Chatham. Agents, W. & J. Mackay & Co., Chatham, Kent. Also sold by Hamilton, Adams & Co., London.

MÉMORIAL DES POUDRES ET SALPÊTRES, publié par les soins du service de poudres et salpêtres avec l'autorisation du ministre de la guerre. Prix pour un an (4 fascicules); Paris et départements, 12 francs; Union postale, 13 francs. Published by Gauthier-Villars et fils, 55 Quai des Grands-Augustins, Paris. Grand in-8, trimestriel.

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HYGIENE.

A TREATISE ON HYGIENE AND PUBLIC HEALTH, 1892. By Thos. Stevenson, M. D., and Shirley F. Murphy, M. D. Philadelphia: P. Blakiston, Son & Co.

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TRAITÉ D'HYGIÈNE MILITAIRE. 1874. Par G. Morache, médecin-major de première classe, professeur agrégé à l'École d'application de médecine et de pharmacie militaire. Paris: J.-B. Baillière et fils, 19 Rue Hauteville.

INTERNATIONAL HEALTH EXHIBITION, London, 1884. The Health Exhibition Literature. Vol. X. General Hygiene. Published by William Clowes & Sons, Limited, 13 Charing Cross, S. W.

GENERAL HYGIENE. By Geo. Rohé, M. D.

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MILITARY LAW. 1886. By Lieut. Col. W. Winthrop, Deputy Judge-Advocate-General of the U. S. Army; author of the Annotated Opinions of the Judges-Advocate-General. Published by W. H. Morrison, law bookseller and publisher, Washington, D. C.

THE CONSTITUTION OF THE UNITED STATES. 1882. By George W. Paschal, LL. D., author of Paschal's Annotated Digest. A Treatise on Charitable Uses, Digest of Decisions, etc. Price, $3. Washington, D. C.: William H. Morrison, publisher, importer, and stationer. Defined and carefully annotated, with an appendix, supplement, and index thereto.

WHARTON'S INTERNATIONAL LAW DIGEST. 1887. Three volumes. Second edition.

MARINE INTERNATIONAL LAW. 1885. By Commander Henry Glass, U. S. Navy. Price, $1. Published in the Proceedings of the U. S. Naval Institute, Vol. XI, No. 3, whole No. 34., 1885. To be obtained from the secretary of the U. S. Naval Institute, Naval Academy, Annapolis, Md. Compiled from various sources.

OUTLINES OF INTERNATIONAL LAW. 1887. By George B. Davis, U. S. Army, assistant professor of law of the U. S. Military Academy. New York: Harper & Bros., Franklin Square. With an account of its origin and sources of its historical development.

A HANDBOOK OF PUBLIC INTERNATIONAL LAW. 1885. By T. J. Lawrence, M. A., LL. M., Deputy Whewell professor of international law in the University of Cambridge; lecturer on international law at the Royal Naval College, Greenwich; late fellow and tutor of Downing College, Cambridge; author of "Some Disputed Questions in Modern International Law." Cambridge: Deighton, Bell & Co. London: George Bell & Sons.

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THE NAVIGATION LAWS OF THE UNITED STATES. 1886. Bureau of Navigation, Treasury Department. Washington: Government Printing Office.

NAVAL SUMMARY COURTS-MARTIAL. 1891. Compiled and arranged by Lieut. S. C. Lemly, U. S. Navy, and Lieut. F. L. Denny, U. S. Marine Corps, February 1, 1891. Price, 50 cents. Published by the Army and Navy Register Publishing Company, National Theater Building, Washington, D. C.

THE PRINCIPLES OF THE LAW OF EVIDENCE, WITH ELEMENTARY RULES FOR CONDUCTING EXAMINATION AND CROSS-EXAMINATION OF WITNESSES. 1882. By W. M. Best, A. M., LL. D. American edition (from seventh English edition). By Charles F. Chamberlayne, of the Boston bar. Boston: Soule & Bugbee, law publishers, 37 Court street. Used at Harvard Law School.

COMPILATION OF LAWS RELATING TO THE NAVY, MARINE CORPS, ETC., FROM THE REVISED STATUTES AND SUBSEQUENT ACTS TO MARCH 3, 1883. 1883. Prepared by John W. Hogg, and published by authority of the Navy Department. Washington: Government Printing Office.

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MARINE BOILER MANAGEMENT AND CONSTRUCTION. By C. E. Stromeyer, Engineer Surveyor to Lloyd's Register, Glasgow. 1893. London: Longmans, Green & Co.

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PROCEEDINGS OF THE DIVISION OF MARINE AND NAVAL ENGINEERING AND NAVAL ARCHITECTURE OF THE INTERNATIONAL ENGINEERING CONGRESS, HELD AT CHICAGO, AUGUST, 1893. Edited by Geo. W. Melville, Engineer in Chief, U. S. Navy, Chairman of Division. 2 vols., 1500 pages, 300 illustrations. John Wiley & Sons, 53 East 10th St., New York.

COAL ENDURANCE AND MACHINERY OF THE NEW CRUISERS. By Prof. I. N. Hollis, late P. A. Engr., U. S. N. 1893. Reprint from Proceedings of American Society of Naval Engineers.

A MANUAL OF THE STEAM ENGINE. By Prof. R. H. Thurston. 1892. Part I, Structure and Theory. Part II, Design, Construction, Operation. Each part 8vo. 900 pages, $7.50, or two parts at once, $12. John Wiley & Sons, 53 East 10th St., New York.

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A TEXT-BOOK ON STEAM AND STEAM ENGINES. 1887. By Andrew Jamieson, principal and professor of engineering, College of Science and Arts, Glasgow; member of the Society of Telegraph Engineers and Electricians; member of the Institute of Civil Engineers; fellow of the Royal Society, Edinburgh; joint author of Electrical Rules, Tables, and Formulæ. London: Charles Griffin & Co., Exeter street, Strand. Second edition. With numerous diagrams, four folding plates, and examination questions. Specially arranged for the use of science and art, City and Guilds of London Institute, and other engineering students.

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ON THE ELEMENTARY RELATION BETWEEN PITCH, SLIP, AND PROPULSIVE EFFICIENCY. 1878. By W. Froude, esq., M. A., F. R. S. Published in Transactions of the Institution of Naval Architects, which are sold by Henry Sothern & Co., 36 Piccadilly, London, W. Read at the nineteenth session of the Institution of Naval Architects, April 11, 1878.

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THE METALLURGY OF STEEL. 1892. By Henry Marian Howe, A. M. (Harvard), S. B. Vol. I. Published by the Scientific Publishing Company, 27 Park Place, New York. Third edition. This book was first published in the Engineering and Mining Journal, commencing 1887. References are given in the book of the authorities used; it would profit most readers to examine them; contains many tables of data. The titles of the eighteen chapters are as follows:

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THE ART OF ELECTROLYPTIC SEPARATION OF METALS, ETC. (Theoretical and Practical.) 1890. By G. Gore, F. R. S., author of the Art of Electro-Metallurgy; The Theory and Practice of Electro-Desposition; Electro-Chemistry; The Art of Scientific Discovery; The Scientific Basis of National Progress. London: The Electrical Printing and Publishing Company, Limited, Salisbury Court, Fleet street, E. C. New York: The D. Van Nostrand Company, 23 Murray street and 27 Warren street.

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A POPULAR TREATISE ON THE WINDS: COMPRISING THE ATMOSPHERE, MONSOONS, CYCLONES, TORNADOES, WATERSPOUTS, HAILSTORMS, ETC. 1889. By William Ferrell, M. A., Ph. D., late professor and assistant in the Signal Service; member of the National Academy of Sciences and of other home and foreign scientific societies. New York: John Wiléy & Sons, 15 Astor Place.

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WEATHER. 1887. By Ralph Abercromby, Fellow of the Royal Meteorological Society, London; Member of the Scottish Meteorological Society, and author of "Principles of Forecasting by Means of Weather Charts." New York: D. Appleton & Co. A popular exposition of the nature of weather changes from day to day.

PRINCIPLES OF FORECASTING BY MEANS OF WEATHER CHARTS. 1885. By Ralph Abercromby, F. R. Met. Soc. London: Printed for Her Majesty's Stationery Office and sold by J. D. Potter, 31 Poultry, and Edward Stanford, Charing Cross. Second edition.

WEATHER FORECASTING FOR THE BRITISH ISLANDS BY MEANS OF A BAROMETER, THE DIRECTION AND FORCE OF THE WIND AND CIRRUS CLOUDS. 1890. By Captain Henry Toynbee, F. R. S., F. R. G. S., F. R. Met. S., Late Marine Superintendent Meteorological Office. London: Edward Stanford, 26 and 27 Cockspur street, Charing Cross.

TEXT-BOOK OF OCEAN METEOROLOGY. 1887. By Alex. Geo. Findlay, F. R. G. S. Price, 12*s*. London: Edited by Staff-Commander W. R. Martin, R. N., Lecturer on Meteorology at the Royal Naval College, Greenwich. Price, 12*s*. Published by Richard Holmes Laurie, 53 Fleet street, E. C., London. This book is compiled from the sailing directories for the oceans of the world.

INSTRUCTIONS FOR OBSERVING CLOUDS ON LAND AND SEA. 1888. By Hon. Ralph Abercromby, F. R. Met. Soc., author of "Principles of Forecasting," "Weather," "Seas and Skies," etc. Price, 18*d*. London: Edward Stanford, Charing Cross, S. W. With photographs and engravings.

ÉTUDES DES MOUVEMENTS DE L'ATMOSPHÈRE. 1890. Par E. Touriner. lieutenant de vaisseau. Price, 1 franc 25 centimes. Broch., in-8. Sold by L. Baudoin et Cie., 30 Rue et Passage Dauphine.

THE SAILORS' HORNBOOK FOR THE LAW OF STORMS. By Henry Piddington, president of the Marine Courts, Calcutta. Price, 8*s*. 9*d*. London: Frederic Norgate, 7 King street, Covent Garden. Edinburgh: Williams & Norgate, 20 Frederick street. Seventh edition. A practical exposition of the theory of the law of storms and its uses to mariners of all classes, in all parts of the world, shown by transparent cards and useful lessons.

HANDBOOK OF THE LAW OF STORMS; BEING A DIGEST OF THE PRINCIPAL FACTS OF REVOLVING STORMS. By William Radcliff Birt, F. R. A. S., author of the Hurricane and Sailors' Guides, etc. London: George Philip & Sons, 32 Fleet street. Liverpool: Caxton Buildings, South John street and 49 and 51 South Castle street. A new edition with important additions. For the use of commanders in Her Majesty's Navy and the Mercantile Marine.

HANDBOOK OF CYCLONIC STORMS IN THE BAY OF BENGAL. FOR THE USE OF SAILORS. 1890. By John Eliot, M. A., Meteorological Reporter to the Government of India. Price, 5 rupees (about $2.50). Calcutta: Printed by the Superintendent of Government Printing, India. Published by the Meteorological Department of the Government of India.

CYCLONES ET TYPHONS. LOI DES DÉPRESSIONS BAROMÉTRIQUE DANS CES OURAGANS ET SES APPLICATIONS À LA MER. 1890. Par F. Ernest Fournier, capitaine de vaisseau. Price, 75 centimes. Paris: Libraire militaire de L. Baudoin et Cie, 30 Rue et Passage Dauphine. Broch., in-8. Publié avec autorisation du ministre de la marine.

REMARKS ON THE PREVAILING STORMS ON THE ATLANTIC COAST. By W. C. Redfield.

NOTES ON THE FORM OF CYCLONES IN THE SOUTHERN OCEAN. By C. M. Meldrum.

THE PILOT CHART OF THE NORTH ATLANTIC OCEAN gives rules for manoeuvering in a cyclone. Issued monthly by the Hydrographic Office.

THE PILOT CHART OF THE NORTH PACIFIC OCEAN. Issued monthly by the Hydrographic Office.

NAVAL SHIP CONSTRUCTION.

THE QUESTION OF SHIPS. THE NAVY AND THE MERCHANT MARINE. By Lieut J. D. J. Kelly, U. S. N. 12 mo. $1. Charles Scribner's Sons, New York.

MODERN SHIPS OF WAR. By Sir E. J. Reed, Rear-Admiral Edward Simpson, U. S. N., and Lieut. J. D. J. Kelly, U. S. N. Quarto, 280 pages. $2.50. Harper & Brothers, Franklin Square, New York.

OUR NAVY; ITS GROWTH AND ACHIEVEMENTS. By Lieut. Commander J. D. J. Kelly, U. S. N. Illustrated by F. S. Cozzens. 250 pages, 24 illustrations. American Publishing Co., Hartford, Conn. Sold only by subscription. Fine table edition, $15. Edition de luxe, $50.

THE RESISTANCE OF SHIPS AND SCREW PROPULSION. 1893. By Naval Constructor D. W. Taylor, U. S. N. New York: MacMillan & Co.

A TEXT-BOOK OF NAVAL ARCHITECTURE FOR THE USE OF OFFICERS OF THE ROYAL NAVY. 1889. By J. J. Welch, Assistant Constructor, Royal Navy; and instructor in naval architecture at the Royal Naval College, Greenwich. Price, 4*s*. Published by order of the Lords Commissioners of the Admiralty, London. Printed for Her Majesty's stationery office by Darling & Son, Limited, 1–3 Great street, Thomas Apostle, E. C. To be purchased either directly or through any bookseller from Eyre & Spottiswoode, East Harding street, Fleet street, E. C.; Adam and Charles Black, 6 North Bridge, Edinburgh; or Hoges, Figgis & Co., 104 Grafton street Dublin. May be obtained from the storekeeper at the Naval Academy. Price, $1.38.

A TREATISE ON THE STABILITY OF SHIPS. 1885. By Sir Edward J. Reed. K. C. B., F. R. S., M. P., etc. London: Charles Griffin & Co., Exeter street, Strand. Numerous diagrams and tables.

A MANUAL OF NAVAL ARCHITECTURE. FOR THE USE OF OFFICERS OF THE ROYAL NAVY, OFFICERS OF THE MERCANTILE MARINE, SHIPBUILDERS, SHIPOWNERS, AND YACHTSMEN. 1893. By W. H. White, C. B., LL. D., F. R. S., Chief Constructor, Royal Navy. Price, £1 4*s*. London: John Murray, Albemarle street. Griffin & Co., The Hard, Portsmouth, England. Third edition, revised and enlarged.

NAVAL ARCHITECTURE: A TREATISE ON LAYING OFF AND BUILDING WOOD, IRON, AND COMPOSITE SHIPS. 1874. By Samuel J. P. Thearle, fellow of the Royal School of Naval Architecture; member of the Institution of Naval Architects; of the controller of the Navy's Department Admiralty, Whitehall. Charge, 7*s*. 6*d*. for the two volumes. London and Glasgow: William Collins, Sons & Co., Limited. Griffin & Co., 2 The Hard, Portsmouth, England. Vol. I, text; Vol. II, plates.

ON A METHOD FOR CALCULATING THE STABILITY OF SHIPS. 1891. By Assistant Naval Constructor D. W. Taylor, U. S. Navy. Price, $1. Proceedings of the United States Naval Institute, Vol. XVII, No. 2, 1891. whole No. 58. Apply to secretary of the institute.

NAVAL PROFESSIONAL PAPERS No. 23. THE RESISTANCE OF SHIPS. 1888. By William Froude, esq., F. R. S. Published by Government Printing Office, Washington. The following subjects are treated in this number, all by the same author except No. 5:

1. Experiments on the resistance of a full-sized ship at various speeds, with H. M. S. *Greyhound*, in 1871.
2. Comparative resistance of long ships of several types. Read at the 17th session of the Institution of Naval Architects, April 7, 1876.
3. Fundamental principles of the resistance of ships.
4. Experiments upon the effect produced on the wave-making resistance of ships by length of parallel middle body. Read at the 18th session of the Institution of Naval Architects, March 23, 1877.
5. Leading phenomena of the wave-making resistance of ships. By R. E. Froude, esq., with discussion. Read at the 22d session of the Institution of Naval Architects, April 8, 1881.
6. Ratio of indicated to effective horse-power, as elucidated by Mr. Denny's M. M. trials at varied speeds. Read at the 17th session of the Institution of Naval Architects, April 7, 1876.

See under Periodicals, Transactions of the Institution of Naval Architects.

Construction du Navire. Par A. Croneau, Ingénieur des Constructions navales. Paris: Gauthier-Villars et fils, Quai des Grands-Augustins, 55.

Canons, Torpilles et Cuirasses. Par A. Croneau, Ingénieur des Constructions navales. Leur installation à bord des batiments de combat. Paris, Gauthier-Villars et fils, Quai des Grands-Augustins, 55.

ARCHITECTURE NAVALE. THÉORIE DU NAVIRE. 1890–1891. By J. Pollard et A Dudebout, Ingénieurs de la marine; professeurs à l'École du génie maritime. Paris, Gauthier-Villars et fils, imprimeurs-libraires du bureau des longitudes de l'École polytechnique, Quai des Grands-Augustins, 55. This is the most complete work on the subject of naval architecture that has ever been written, and probably the most authentic. Four volumes (sold separately).

Volume I. Calcul des éléments géométriques des carènes droites et inclinées. Géométrie du navire. 1890. Price, 13 francs.

Volume II. Statique du navire. Dynamique du navire dans le mouvement de roulis en mer calme. 1891.

Volume III. Dynamique du navire dans le mouvement de roulis sur houle. Dynamique du navire dans le mouvemen trectiligne horizontal. Résistance des carènes.

Volume IV. Dynamique du navire dans le mouvement curviligne horizontal. Propulsion. Vibrations des coques des navires à hélice.

NAVIGATION, SURVEYING, ETC.

THE NEW AMERICAN PRACTICAL NAVIGATOR. Edition of 1880. By Nathaniel Bowditch, LL. D., Bureau of Navigation. Published only by the Navy Department. 8vo.

BOWDITCH'S USEFUL TABLES. 1890. By Nathaniel Bowditch, LL. D., Bureau of Navigation. Published only by the Navy Department. 8vo. New edition.

THE DEVELOPMENT OF GREAT CIRCLE SAILING. 1889. By G. W. Littlehales Price, $1. Hydrographic Office.

TABLE OF MERIDIONAL PARTS FOR THE TERRESTRIAL SPHEROID, Compression $\frac{1}{293.465}$. 1889. By G. W. Littlehales and J. S. Siebert, Bureau of Navigation. Hydrographic Office.

WRINKLES IN PRACTICAL NAVIGATION. 1881. By Capt. S. T. S. Lecky, R. N. R., Fellow of the Royal Astronomical Society; Fellow of the Royal Geographic-

al Society; Extra Master; passed in steam, compass adjustment, etc. Price, 15*s*. London: George Philip & Son, 32 Fleet street, E. C. Liverpool: Caxton Buildings, South John street, and Atlas Buildings, 49 and 51 South Castle street. Also Griffin & Co., 2 The Hard, Portsmouth, England. With 76 illustrations.

THE PRACTICE OF NAVIGATION AND NAUTICAL ASTRONOMY. By Henry Raper, Lieutenant, R. N., F. R. A. S., F. R. G. S. Price, 16*s*. London: Published by J. D. Potter, 31 Poultry and 11 King street, Tower Hill. Griffin & Co., 2 The Hard, Portsmouth, England.

AZIMUTH—A TREATISE ON THIS SUBJECT. 1877. By Joseph Edgar Craig, Lieutenant-Commander, U. S. Navy. New York: John Wiley & Sons, 51 Astor Place. A study of the astronomical triangle and the effect of errors in the data. Illustrated by loci of maximum and minimum errors.

A PRACTICAL AID TO THE NAVIGATOR. By Lieut. E. W. Sturdy, U. S. Navy. Price, $2. New York: John Bliss & Co. The book is intended simply to assist a practical navigator in finding his position at sea by improved methods given in works on navigation.

NAVIGATION. 1888. By Lieut. Commander Asa Walker, U. S. Navy. Price, $1.35. Baltimore: Isaac Friedenwald. To be obtained from the storekeeper at the U. S. Naval Academy. Prepared as a text-book at the U. S. Naval Academy.

A TREATISE ON NAVIGATION AND NAUTICAL ASTRONOMY. 1888. Compiled by Staff-Commander W. R. Martin, R. N., instructor in nautical surveying, navigation, and compass adjustment, lecturer on meteorology at the Royal Naval College, Greenwich, and formerly Naval Assistant to the Hydrographer. London: Longmans, Green & Co., and New York: 15 East Sixteenth street. Sanctioned for use in the Royal Navy by the Lords Commissioners of the Admiralty.

REPORT ON THE TELEGRAPHIC DETERMINATION OF DIFFERENCES OF LONGITUDE IN THE WEST INDIES AND CENTRAL AMERICA. 1877. By Lieut. Commander F. M. Green, U. S. Navy. Washington: Government Printing Office. Prepared at the U. S. Hydrographic Office (No. 65) by order of Commodore R. H. Wyman, U. S. Navy, Hydrographer. Not for sale. Apply to the U. S. Hydrographic Office, Bureau of Navigation, Navy Department.

TELEGRAPHIC DETERMINATION OF LONGITUDES IN JAPAN, CHINA, AND THE EAST INDIES; EMBRACING THE MERIDIANS OF YOKOHAMA, NAGASAKI, VLADIVOSTOK, SHANGHAI, AMOY, HONGKONG, MANILA, CAPE ST. JAMES, SINGAPORE, BATAVIA, AND MADRAS, WITH THE LATITUDE OF THE SEVERAL STATIONS. 1883. By Lieut. Commanders F. M. Green, C. H. Davis, and Lieut. J. A. Norris, U. S. Navy, in 1881 and 1882. Not for sale. Published by the order of Capt. J. G. Walker, U. S. Navy, Chief of the Bureau of Navigation, Navy Department. Washington: Government Printing Office.

REPORT ON THE TELEGRAPHIC DETERMINATION OF LONGITUDES IN MEXICO, CENTRAL AMERICA, AND THE WEST COAST OF SOUTH AMERICA. 1885. By Lieut. Commander C. H. Davis, Lieuts. J. A. Norris and Charles Laird, U. S. Navy. Bureau of Navigation. Not for sale. Furnished by Bureau of Equipment or Hydrographic Office. This contains in one chapter a descriptive treatise on the various methods employed in the exchange of telegraphic time signals over submarine lines.

REPORT OF THE TELEGRAPHIC DETERMINATION OF LONGITUDE ON THE EAST COAST OF SOUTH AMERICA. 1880. By Lieut. Commander F. M. Green, U. S. Navy. Not for sale. Bureau of Navigation. Furnished by Bureau of Equipment or Hydrographic Office.

HANDY BOOK OF THE STARS USED IN NAVIGATION. HOW TO FIND THEM AND HOW TO USE THEM IN GETTING THE SHIP'S POSITION AND CORRECTION OF THE COMPASS. By Capt. W. B. Whall, younger brother, Trinity House; Extra

Master; Author of Handy Book of the Tides. Price, 7*s*. 6*d*. London: George Philip & Son, 32 Fleet street, E. C. Liverpool: Philip, Son & Nephew, 45 to 51 South Castle street.

NAUTICAL SURVEYING. 1890. By the late Vice-Admiral Shortland, LL. D., late fellow of Pembroke College, Cambridge. London and New York: Macmillan & Co. Published by the author's widow and children.

PRACTICAL MARINE SURVEYING. 1889. By Harry Phelps, ensign, U. S. Navy. New York: John Wiley & Sons, 15 Astor Place. Text-book, Naval Academy.

CHART AND CHART-MAKING. By Lieut. J. E. Pillsbury, U. S. Navy. Proceedings of the U. S. Naval Institute, No. 29.

SPHERICAL AND PRACTICAL ASTRONOMY. By Chauvenet. Apply to storekeeper, Naval Academy.

ICE AND ICE MOVEMENTS IN THE BERING SEA AND ARCTIC BASIN. 1890. By Ensign Edward Simpson, U. S. Navy. Hydrographic Office.

THE USE OF OIL TO LESSEN THE DANGEROUS EFFECT OF HEAVY SEAS. 1887. Compiled by Lieut. E. B. Underwood, U. S. Navy. Hydrographic Office.

THE SEXTANT AND OTHER REFLECTING MATHEMATICAL INSTRUMENTS. 1891. By F. R. Brainard, U. S. Navy. D. Van Nostrand & Co., New York. Science Series No. 101. Contains 33 illustrations, with practical hints, suggestions, and wrinkles on errors, adjustments, and use of such instruments.

DESCRIPTION ET USAGE DES INSTRUMENTS NAUTIQUES. MINISTÈRE DE LA MARINE. 1889. Par M. E. Guyon, capitaine de frigate, chef du service des instruments nautiques au service hydrographique de la marine. Paris: Imprimerie Nationale.

ORDNANCE.

AMMUNITION.

TREATISE ON AMMUNITION. 1887. Printed by order of the Secretary of State for War. Price, 6*s*. To be purchased either directly or through any bookseller from Eyre & Spottiswoode, East Harding street, Fleet street, E. C., London; or Adam & Charles Black, North Bridge, Edinburg; or Hodges, Figgis & Co., 104 Grafton street, Dublin. Fourth edition, corrected to January 1, 1887.

GUNS.

ARTILLERY: ITS PROGRESS AND PRESENT POSITION. By E. W. Lloyd, late R. N., and A. G. Adcock, late R. A. 1893. 463 pages, 334 illustrations. A comprehensive work on guns, ammunition, and all artillery appliances. Treats principally of English ordnance. Portsmouth, England, J. Griffin & Co., 2 The Hard.

EXTERIOR BALLISTICS. 1893. By Lieut. Comdr. R. R. Ingersoll, U. S. Navy. Price, $1.25. Printed by Isaac Friedenwald, No. 32 South Paca street, Baltimore, Md. Second edition revised and partially rewritten. Prepared and arranged for the use of the cadets at the U. S. Naval Academy. To be obtained from the storekeeper, U. S. Naval Academy.

INTERIOR BALLISTICS. 1891. By Lieuts. J. F. Meigs and R. R. Ingersoll, U. S. Navy. Price, $1.18. Printed by Isaac Friedenwald, No. 32 South Paca street, Baltimore, Md. A text-book for the use of naval cadets at the U. S. Naval Academy. To be obtained from the storekeeper, U. S. Naval Academy.

THE ELASTIC STRENGTH OF GUNS. 1891. By Lieuts. J. F. Meigs and R. R. Ingersoll, U. S. Navy. Price, 70 cents. Printed by Isaac Friedenwald, No. 32 South Paca street, Balimore, Md. Prepared and arranged for the use of cadets at the U. S. Naval Academy. To be obtained from the storekeeper, U. S. Naval Academy.

TEXT-BOOK OF ORDNANCE AND GUNNERY. By Lieut. Commander R. R. Ingersoll, U. S. Navy. 1894. Deutsch & Co., Baltimore. Text-book at U. S. Naval Academy. Price, $2.65. To be obtained from the storekeeper, U. S. Naval Academy.

VELOCITY AND PRESSURE IN GUNS. By Ensign J. H. Glennon, U. S. Navy, Instructor in Ordnance and Gunnery, U. S. Naval Academy. Price, $1. Proceedings of the U. S. Naval Institute.

ACCURACY AND PROBABILITY OF FIRE. 1888. By Ensign J. H. Glennon, U. S. Navy. Price, $1. Printed by Isaac Friedenwald, No. 32 South Paca street, Baltimore, Md. Prepared for the use of cadets at the U. S. Naval Academy.

TRAITÉ DE BALISTIQUE EXPÉRIMENTAL. 1884. Par Hélie, professeur à l'École d'artillerie de la marine. Prix, 18 francs. Publié par Gauthiers-Villars et fils, 55 Quai des Grands-Augustins, Paris. Deuxième édition, beaucoup augmentée, avec la collaboration de M. Hugoniot, capitaine d'artillerie de la marine. Deux vol. in-8, avec figures et nombreux tableaux. Ouvrage publié sous les auspicies du ministre de la marine. (Honoré d'un grand prix en 1885 par l'Académie des Sciences.)

NOMENCLATURE OF STEEL B. L. R. GUNS AND CARRIAGES AND MOUNTS FOR HOTCHKISS GUNS. Latest edition, 1890. Printed at the Torpedo Station, Newport. Furnished to ships by Bureau of Ordnance. Edition limited. Contains many plates. The book gives the nomenclature of such guns and carriages only as are used in the U. S. Navy. The names of the parts of the Colt's double-action navy revolver are also given.

MODERN FRENCH ARTILLERY: (THE ST. CHAMOND, DE BANGE, CANET, AND HOTCHKISS SYSTEMS.) *1892. By James Dredge. Price, £2 10*s*. London: Offices of Engineering, 35 and 36 Bedford street, Strand, W. C. New York: John Wiley & Sons, 53 East Tenth street. Imperial quarto, handsomely bound in half morocco, 500 pages of text, tables, and plates, and over 700 illustrations. The work is provided with a carefully prepared and copious index, and also contains many illustrations of French war ships.

CHAPTERS.

I.—Introductory.
II.—Steel Ordnance.
III.—Breechloading Mechanism.
IV.—The present Condition of French Ordnance.
V.—The St. Chamond Steel Works.
VI.—The De Bange System of Ordnance.
VII.—The Forges et Chantiers de la Mediterranée.
VIII.—Hotchkiss Machine and Quick-Firing Guns.
IX.—The French Navy.

MODERN UNITED STATES ARTILLERY. 1892. A series of articles, well illustrated, in Engineering for 1892. London: Offices of Engineering, 35 and 36 Bedford street, Strand.

GENERAL INFORMATION SERIES:

No. V, pages 211 *et seq.* Edition exhausted.
No. VI, Chap. IV. 8-inch B. L. R. for the U. S. Navy, and notes, pages 297 *et seq.*
No. VII, pages 336 *et seq.* Edition exhausted.
No. VIII, Chap. IV. Development of the high-power gun. Chap. V. Naval gunnery, and notes, pages 375 *et seq.* Edition exhausted.
No. IX, pages 73 *et seq.* Edition exhausted.
No. X, Chap. III. Edition exhausted.
No. XI, Chap. III.
No. XII, Chap. V.

* Engineering for 1892 contains a series of articles on "Modern United States Artillery," well illustrated, which will probably appear in book form.

RAPID-FIRE GUNS.

THE NEWEST FACTOR IN NAVAL WARFARE. 1891. By W. Laird Clowes. Price, 1s. Published in the United Service Magazine for February, 1891. To be obtained from the International News Company, New York.

UNITED STATES PATENT SPECIFICATIONS. Price, 25 cents. To be obtained from the Commissioner of Patents, Washington, D. C. In asking for specifications they should be referred to by number. The Official Gazette of the United States Patent Office (issued weekly, and probably to be found in every public library) contains the number and a short description of each patent issued. Annual subscription for Gazette, $5.

GENERAL INFORMATION SERIES:

No. V, pages 231 to 238. Edition exhausted.

No. VI, page 312. Edition exhausted.

No. VII, pages 336, 338, 359 to 365. Edition exhausted.

No. VIII, pages 397 to 402. Edition exhausted.

No. IX, pages 101 to 113 and 325 to 336, inclusive, being an article entitled "The development of rapid-fire guns for naval use." Edition exhausted.

No. X, Chap. III. Edition exhausted.

No. XI, Chap. III.

No. XII, Chap. V.

SMALL ARMS.

LOS FUSILES MAUSER ADOPTADOS EN EUROPA Y EN AMERICA. By D. José Boado y Castro, Capitan de Artilleria dela Fabrica nacional de armas de Oviedo. 1894. Pardo, Gusano y Compañia, San José, 6. 1 peseta. 7.65 mm. Mauser, 1890–'91 models. Full description of each part.

LES ARMES À FEU PORTATIVES DES ARMÉES ACTUELLES ET LEURS MUNITIONS. 1894. Par un officier supérieur. 131 illustrations. Paris: L. Baudoin, 30 rue Dauphine.

LES ARMES DE PETIT CALIBRE, ÉTUDE COMPARATIVE, and LES ARMES DE PETIT CALIBRE. FUSILS EN ESSAI ET EN CONSTRUCTION. Par Capt. J. de Monbrison. 1894. Paris: L. Baudoin, 30 rue Dauphine.

DE LA RASANCE DES FUSILS DE PETIT CALIBRE ET DE SES CONSÉQUENCES TACTIQUES. 1892. Par E. Paquié, Colonel du 11e Régiment d'Infanterie. Paris: L. Baudoin, 30 rue Dauphine.

NEUE GEWEHRE. Von R. Wille, General-Major z. D. March, April, and May numbers of Internationale Revue, 1893, über die gesammten Armeen und Flotten. Rathenow, Prussia. Ferdinand v. Witzleben-Wendelstein.

ALLGEMEINE WAFFENKUNDE FÜR INFANTERIE. MIT BESONDERER BERÜCKSICHTIGUNG DER NEUESTEN KRIEGS-HANDFEUERWAFFEN DER MODERNEN STAATEN. Neue Folge von 1891 zum Grundwerke von 1888. Von Rudolf Schmidt, Oberst. Bern: Verlag von Schmidt, Francke & Co. (vorm. J. Dalp'sche Buchhandlung). Tafeln 24–30 mit Abbildungen in Farbendruck. Contains colored plates of the different parts of small arms used in the armies of France, Italy, Holland, Turkey, Austria-Hungary, England, and Switzerland, with descriptions of same. The Danish and Belgian small arms are also described. This work appears in several principal languages, and carries the subject on from 1888.

LES NOUVELLES ARMES À FEU PORTATIVES ADOPTÉES COMME ARMES DE GUERRE DANS LES ÉTATS MODERNES. 1889. Par Rodolphe Schmidt, colonel d'infanterie, directeur de la fabrique fédérale d'armes à Berne. Bâle-Genève-Lyon, H. Georg., libraire-éditeur. Description détaillée, précedée d'une étude générale des armes d'infanterie et accompagnée d'un atlas contenant 100 figures chromolithographiques. Addition to the above by the same author published in 1891, containing drawings and descriptions of latest rifles.

DAS KLEINSTE KALIBER. By Professor Hebler. Zürich: A. Müller.

TREATISE ON MILITARY SMALL ARMS AND AMMUNITION, WITH THEORY ON THE MOTION OF A RIFLE BULLET. 1888. Compiled at the School of Musketry with the assistance of the superintendent's royal laboratory, royal small-arms factory, royal gunpowder factory. A text-book for the army. Price, 4*s.*; interleaved, 4*s.* 9*d.* To be obtained either directly or through any bookseller from Eyre & Spottiswoode, East Harding street, Fleet street, E. C., London; Adam & Charles Black, 6 North Bridge, Edinburgh; Hodges, Figgis & Co., 104 Grafton street, Dublin.

ARMIADA REPETIZIONE. 1890. By Ippolito Viglezzi, lieutenant-colonel of artillery. Published by Voghera Carlo, Rome. May be obtained through B. F. Stevens, No. 4 Trafalgar Square, London. Vol. I, text; Vol. II, plates.

GENERAL INFORMATION SERIES, OFFICE OF NAVAL INTELLIGENCE:

No. VI, pages 136 to 151, "Recent practice in small arms," and 152 and 199, "Musketry instructions at home and abroad."

No. VII, pages 366 to 372. Edition exhausted.

No. VIII, pages 402 to 412. Edition exhausted.

No. IX, pages 125 to 130. Development of rapid-fire guns. Edition exhausted.

No. X, Chap. III. Edition exhausted.

No. XI, Chap. III.

No. XII, Chap. VI.

PROJECTILES.

TREATISE ON AMMUNITION. 1887. Chapters 13 to 20, inclusive. Printed by order of the Secretary of State for War. Price, 6*s.* London: Harrison & Sons, St. Martin's Lane. Can be purchased either directly or through any bookseller from Eyre & Spottiswoode, East Harding Street, Fleet street, E. C., or Adam & Charles Black, North Bridge, Edinburgh; or Hodges, Figgis & Co., 104 Grafton street, Dublin. Fourth edition corrected to January 1, 1887.

COURS D'ARTILLERIE. LES PROJECTILES. 1881. Par E. Jouffret, chef d'escadron d'artillerie, Fontainebleau. Typographie de Ernest Bourges, imprimeur de l'École d'Application, 32 rue de l'Arbre-Sec. Used at l'École d'Application et d'Artillerie et du Génie.

LE NOUVEAU MATÉRIEL NAVAL. Vol. 1. 1889. Chap. 3, pp. 127–156. See books under heading Miscellaneous.

UNITED STATES PATENT SPECIFICATIONS. See under heading Ordnance Rapid-fire Guns.

TACTICS.

ELEMENTARY NAVAL TACTICS. By Comdr. W. Bainbridge-Hoff, U. S. Navy. 1894. John Wiley & Sons, 53 East Tenth street, New York.

INFLUENCE OF SEA POWER UPON THE FRENCH REVOLUTION AND EMPIRE. 1892. By Capt. A. T. Mahan, U. S. Navy. 2 vols. Boston: Little, Brown & Co.

L'ÉLECTRICITÉ ET LA DEFENSE DES CÔTES. 1894. By Georges Dávy, with a preface by M. le Contre-Amiral Reveillère. Paris: Grelot, 18 rue des Fossés-St.-Jacques. 348 pages. 5 frs.

THE DEFENSE OF CHARLESTON HARBOR. By J. Johnson, Major, C. S. A. 1890. Walker, Evans & Cogswell Co. Charleston, S. C.

THE INFLUENCE OF SEA POWER UPON HISTORY; 1660–1783. 1890. By Capt. A. T. Mahan, U. S. Navy. Boston: Little, Brown & Co. "The definite object proposed in this work is an examination of the general history of Europe and America with particular reference to the effect of sea power upon the course of that history. * * *

NAVAL WARFARE; ITS RULING PRINCIPLES AND PRACTICE HISTORICALLY CONSIDERED. 1891. By Rear-Admiral P. H. Colomb, Gold Medalist Royal United Service Institution and Lecturer on Naval Strategy and Tactics at the Royal Naval College at Greenwich. London: W. H. Allen & Co., Limited, 13 Water-

loo Place, and at Calcutta. The eighteen chapters treat of the following subjects:

The nature of naval war.
The struggle for the command of the sea.
The differentiation of naval force.
Attempts to gain command of the sea, with definite ulterior purpose.
The conditions under which attacks on territory from the sea succeed or fail.
Attacks on territory from the sea.

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EXAMPLES, CONCLUSIONS, AND MAXIMS OF MODERN NAVAL TACTICS. 1884. By Commander William Bainbridge Hoff, U. S. Navy. Washington: Government Printing Office. No. III of the General Information Series of the Office of Naval Intelligence, U. S. Navy Department. Published also by Griffin & Co., No. 2 The Hard., Portsmouth, England. Price, 10*s*. 6*d*.

A TREATISE ON FUTURE NAVAL BATTLES AND HOW TO FIGHT THEM, AND ON OTHER NAVAL TACTICAL SUBJECTS. 1885. G. Elliott. Price, 14*s*. 122 pp., 8vo., with 25 plates and 6 maps. Chapter I. Line-of-battle ships and torpedo vessels. Chapters II and III. Ram and Gun Attack and Defense. Chapter VII. Practical remarks on designs for ships of war. Chapter IX. Cellular Deck Protection, etc.

COAST DEFENSE BY GUNBOATS. 1887. By G. Elliot. Price, 7*s*. 21 pp., 8vo, with 1 plate and 7 figures. Published by the Journal of the Royal United Service Institution. See under Miscellaneous; Periodicals.

LECTURE ON THE TURNING POWERS OF SHIPS. 1882. By W. H. White, Assistant Constructor, R. N. Government Printing Office, Washington. Reprinted as Navy Scientific Paper No. 7, from the Journal of the Royal United Service Institution. May be obtained from the Bureau of Equipment, Navy Department.

THE RAM. THE PROMINENT FEATURE OF FUTURE NAVAL VICTORIES. 1884. By George Elliot. Price, 5*s*. London: Published by the Journal of the Royal United Service Institution. See under Miscellaneous; Periodicals.

SPEED, TURNING, AND MANŒUVRING TRIALS FOR VESSELS OF THE UNITED STATES NAVY. GENERAL ORDER No. 314. 1883. Washington: Government Printing Office.

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NAVAL TACTICS. Translated from the French by Capt. Augustus Phillimore. Price, 10*s*. London: Harrison & Sons, 59 Pall Mall, S. W. Contains general instructions, principles of chasing, naval tactics under steam and sail. 8vo., cloth.

LES TORPILLEURS, LA GUERRE NAVALE ET LA DÉFENSE DES CÔTES. 1888. Par le Vice-Amiral Bourgois. Paris, Librairie de la Nouvelle Revue, 18 Boulevard Montmartre. Deuxième édition.

NOUVELLES BASES DE TACTIQUE NAVALE. Par l'Amiral Grégoire Boutakov. Traduit du russe par H. de la Planche, lieutenant de vaisseau. Paris: Arthus Bertrand, éditeur, Librairie Maritime et Scientifique, rue Hautefeuille, 21. Ouvrage couronné par l'Académie des Sciences de St.-Pétersbourg, publié par ordre de S. Exc. le Marquis de Schassloup-Laubat, Ministre de la Marine et des Colonies. Accompagné de 26 planches gravées, dont 15 en couleur, et de nombreuses figures intercalées dans le texte.

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PUISSANCE MILITAIRE DES ÉTATS DE L'EUROPE. 1893. Par J. Molard. Considérations militaires—Organisations défensives—Chemins de fer—Armées et marines. Paris, Plon Nourrit et Cie.

UEBER KRIEGSFÜHRUNG ZUR SEE. EINE STRATEGISCHE STUDIE AN DER HAND DER ENGLISCHEN FLOTTEN-MANÖVER IM JAHRE. 1888. Von Stenzel, Capitän, zur See, a. D. Berlin, Weigandt und Grieben, Trebbinerstrasse, 1.

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TORPEDOES FOR NATIONAL DEFENSE. 1886. By Lieut. W. H. Jaques, U. S. Navy. New York and London; G. P. Putnam's Sons, The Knickerbocker Press. A practical and precise review of these weapons, their usefulness, application, cost and most efficient types, together with the results obtained at official trials, and a description and comparison of the Sims, Whitehead and Howell, based upon official reports and expert testimony. Illustrated.

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PROFESSIONAL PAPERS OF THE CORPS OF ENGINEERS, U. S. ARMY, NO. 23. REPORT UPON EXPERIMENTS AND INVESTIGATIONS TO DEVELOP A SYSTEM OF SUBMARINE MINES FOR DEFENDING THE HARBORS OF THE UNITED STATES. 1881. Submitted to the Board of Engineers by Lieut. Col. Henry L. Abbot, Corps of Engineers, brevet brigadier-general U. S. Army, member of the Board. Washington: Government Printing Office.

ART MILITAIRE SOUS-AQUATIQUE. LES TORPILLES. 1883. Par le Major H. de Sarrepont. Prix, 12 francs. Paris, Librairie Militaire de L. Baudoin et Cie, Libraires-Éditeurs, successeurs de J. Mumaine, 30 Rue et Passage Dauphine. 3e édition, avec supplément.

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MANUEL DE MÉCANICIEN-TORPILLEUR. 1890. Publié par ordre du Ministre de la Marine. Prix, 4 francs 50 centimes. Paris: L. Baudoin et Cie, 30 rue Dauphine. 1 vol. in-8, avec planches, relié. 2e et 3e parties. Pomes de Compression. Appareil photo-électrique.

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WORKS OF REFERENCE, ETC.

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THE NAVAL ANNUAL, 1886–1894. By Lord Brassey, K. C. B. Price 10*s.* 6*d.* Portsmouth: J. Griffith & Co., The Hard. London agents, Simpkin, Marshall & Co.; New York agents, Van Nostrand & Co. In five parts. P. S. King & Son, 5 King street, Westminster, London, S. W., also sell the book.

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THE BOAT SAILER'S MANUAL. 1886. By Lieut. E. F. Qualtrough, U. S. Navy. New York: Charles Scribner's Sons.

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ALMANACH FÜR DIE K. U. K. KRIEGS-MARINE, 1894. Herausgegeben von der Redaction der "Mittheilungen aus dem Gebiete des Seewesens." Pola: Wien, Gerold & Co., in Comm. Geb. 4 marks. An annual.

CARNET DE L'OFFICIER DE MARINE. Annual. 1894. Fourteenth year. Vol. in-8 relié., 3 francs 50 centimes. Berger-Levrault et Cie., 5 Rue des Beaux-Arts, Paris.

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AN ELEMENTARY TREATISE ON ANALYTICAL MECHANICS, WITH NUMEROUS EXAMPLES. 1885. By Edward A. Bowser, LL. D., professor of mathematics and engineering in Rutgers College. New York: D. Van Nostrand, 23 Murray street and 27 Warren street. Second edition.

THE ELEMENTS OF MECHANISM. 1880. By T. M. Goodeve, M. A. Barrister at law, Lecturer on Applied Mechanics at the Royal School of Mines, Author of an Abstract on Patent Cases, A Text-Book on the Steam Engine, The Principles of Mechanics, etc. London: Longmans, Green & Co. New edition, revised and enlarged.

APPLIED MECHANICS. 1889. By Gaetano Lanza, S. B., C. and M. E., Professor of Theoretical and Applied Mechanics, Massachusetts Institute of Technology. New York: John Wiley & Sons, 16 Astor Place. Third edition. A treatise on strength and stability, but contains much other matter.

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